Specifications
for

TASS Complex

Camp Williams – Utah National Guard

DFCM Project No. 95059480
April 16, 2007

Final Bid Documents

Volume II
Divisions 21 - 33

WPA
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SECTION 210800 - COMMISSIONING OF FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

010800 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

211000 Commissioning of Water Based Fire Suppression Systems

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 010800, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 010800, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Water –Based Fire-Suppression Systems						
Pressure Testing		n/a				
Cleaning and Flushing		n/a				
Test Certificate		n/a				
System Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.
B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.
C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.
D. Indicates that CA has received and approved proposed installation and start-up documentation.
E. Date the completed documents are received by the CA from the responsible Contractor.
F. Indicates that CA has received and approved completed documentation.
G. Notes on status of forms, irregularities and rework needed.

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Water-Based Fire-Suppression Systems
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Piping installed with slope to drain.

Unions installed on all equipment requiring disconnects for servicing.

Dielectric unions installed on all dissimilar materials.

Pressure gages installed at all specified points, gage range as specified.

Mechanical supporting devices installed at specified locations and spacing.

Valves provided and installed per specification in regards to connection style and size.

Valves installed for area and group isolation, maintenance isolation and service disconnects.

Double detector check valve is complete, tested and tagged.

Tamper and alarm devices are installed and connected to fire alarm system

Start-Up:

Commissioning Authority notified for witness of start-up.

Piping is complete, flushed, and pressure tested.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
	Responsible Contractor	Proposed Test Forms Received	OK	Testing Complete	OK	Notes
Fire-Suppression Systems						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Fire Sprinkler System
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Functional Tests:

1) Wet System
   a) System trip
   b) Water gong or alarm
   c) Alarm reporting
   d) Tamper reporting

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	Responsible Contractor	Proposed Agenda Received	OK	Training Performed	OK	Closeout Form Received	OK	Notes
Fire-Suppression Systems								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Building IAQ flush out completed and accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

Not Used. Communications contractor to provide test report format.

END OF SECTION 210800

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SECTION 210800 - COMMISSIONING OF FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

010800 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

211000 Commissioning of Water Based Fire Suppression Systems

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 010800, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 010800, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Water –Based Fire-Suppression Systems						
Pressure Testing		n/a				
Cleaning and Flushing		n/a				
Test Certificate		n/a				
System Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.
B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.
C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.
D. Indicates that CA has received and approved proposed installation and start-up documentation.
E. Date the completed documents are received by the CA from the responsible Contractor.
F. Indicates that CA has received and approved completed documentation.
G. Notes on status of forms, irregularities and rework needed.

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Water-Based Fire-Suppression Systems
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Piping installed with slope to drain.

Unions installed on all equipment requiring disconnects for servicing.

Dielectric unions installed on all dissimilar materials.

Pressure gages installed at all specified points, gage range as specified.

Mechanical supporting devices installed at specified locations and spacing.

Valves provided and installed per specification in regards to connection style and size.

Valves installed for area and group isolation, maintenance isolation and service disconnects.

Double detector check valve is complete, tested and tagged.

Tamper and alarm devices are installed and connected to fire alarm system

Start-Up:

Commissioning Authority notified for witness of start-up.

Piping is complete, flushed, and pressure tested.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
	Responsible Contractor	Proposed Test Forms Received	OK	Testing Complete	OK	Notes
Fire-Suppression Systems						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Fire Sprinkler System
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Functional Tests:

1) Wet System
   a) System trip
   b) Water gong or alarm
   c) Alarm reporting
   d) Tamper reporting

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	Responsible Contractor	Proposed Agenda Received	OK	Training Performed	OK	Closeout Form Received	OK	Notes
Fire-Suppression Systems								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Building IAQ flush out completed and accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

Not Used. Communications contractor to provide test report format.

END OF SECTION 210800

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SECTION 211000 – WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the contract apply to this section.

B. Technical sections which describe related work such as Division 28 “Fire Alarm System” apply to this section.

C. Other Division 21 specifications apply to this section.

1.2 SUMMARY:

Furnish all materials, equipment and supplies and perform all work and operations to construct and make functional a fire sprinkler system to provide fire protection of all areas of the new Administration and Education Building and Bay Billeting Building located at the Camp Williams Utah National Guard Facility in Riverton, Utah. The system design shall meet the requirements of NFPA 13 and the Unified Facilities Criteria (UFC) and be in accordance with the bid drawings and specifications. Reference to other specifications, codes, standards or manuals which are a part of these specifications, but are not included herein, shall be the latest adopted edition of these publications.

1.3 QUALITY ASSURANCE:

A. Materials, devices and equipment shall be Underwriters Laboratories listed or Factory Mutual approved for use in fire protection systems.

B. Installer: The sub-contractor for each of the fire protection systems shall be duly licensed by the state, country and city in which the project is being constructed. The sub-contractor must be engaged in the installation of automatic fire protection systems and be fully familiar with all local conditions, specified codes and requirements.

C. Designer: The designer for the fire sprinkler system shall be a staff employee of the "Installer" and shall be a Utah State licensed fire protection engineer or a Certified Engineering Technician in Fire Protection (NICET III). The Certification shall be active during the entire contract period. The designer shall certify that the drawings and installation are in accordance with the intent of the plans and specifications. The designer shall make a complete and final inspection of the installation, including operating all alarms, control valves checking all piping, seismic bracing, hangers, etc.

After checking all components of the system, he shall provide a letter stating that the installation is complete, operational and in accordance with approved plans and specifications. If changes have been made in the installation since the plans were approved, the designer shall correct the shop drawings and provide as-built drawings to the Owner with the letter.

1.4 SUBMITTALS:

A. Shop Drawings: The fire sprinkler contractor shall prepare complete shop drawings for each and all systems. Piping layouts shall be coordinated with all other trades. Shop drawings shall be coordinated with structure and with all other trades. Show ceiling grid, lights, grilles, registers and diffusers, smoke detectors, sound speakers, etc. Draw sections to show relative elevations of piping ductwork, conduit, cable trays, ceiling grid, beams, etc. Show heads symmetrically related to ceiling patterns and show heads centered in tiles in grid. The shop drawings shall contain, as a minimum, the information outlined and listed in NFPA 13 chapter 6. Submit copies of each drawing and hydraulic calculations to each Authority Having Jurisdiction for review prior to starting work. Final design shall incorporate all requirements of the AHJ's as summarized by the Engineer. Work only from reviewed documents.

B. Hydraulic Calculations: Furnish complete hydraulic calculations for the hydraulically most remote area of each different occupancy classification on each floor level.

C. Descriptive Data: Descriptive data shall be submitted on the following items of material and/or equipment. Such data shall consist of manufacturer's or supplier's catalog information in sufficient detail to allow the Laboratory to determine that the material and/or equipment meet the specification requirements, or is equal to that specified.

1. All valves, trim, pipe and sprinkler heads.

D. Upon completion of installation submit to Architect two copies each:

1. NFPA 13, "Contractor's Material & Test Certificate for Aboveground Piping."

2. As-built shop drawings with designer's signature and certification number.

1.5 WORK INCLUDED:

A. Fire sprinkler system per NFPA 13 and the UFC for all areas of the Administration and Education Building and Bay Billeting Building located at the Camp Williams Utah National Guard Facility in Riverton, UT. Work includes but is not limited to:

1. Design and installation drawings, including hydraulic calculations.
2. Underground piping, sprinkler riser, pipe, fittings, hangers and sprinklers.
3. Drain and test valves.
4. Signs, spare heads, earthquake bracing, sprinkler escutcheons, testing and documentation.

1.6 RELATED WORK:

A. Painting.
B. Excavation and Backfill.
C. Electrical Materials and Methods.
D. Fire Alarm and Detection.

1.7 SYSTEM DESCRIPTION:

A. Underground Piping:

1. Work to begin by connecting to 6" underground main provided 5'-0" from the building by others. Provide underground piping to supply each of the sprinkler risers that will be located in the designated Mechanical Rooms in each of the two buildings.

a. Pipe shall be run with a minimum of bends, fittings, etc.
b. Minimum depth of pipe cover shall be 5 feet or per local ordinance, whichever is greater.
c. All changes in direction shall be secured against movement.
d. Flange X spigot piece shall be secured to the underground elbow with steel rods.
e. All rods, bolts and other ferrous parts shall be protected from corrosion.

B. Interior Piping:

1. Provide an automatic, wet-pipe fire sprinkler system per NFPA 13 and the UFC for fire protection of all areas of the building. Work includes but is not limited to the following:

a. System shall be supplied by a new sprinkler riser complete with control valve with tamper switch, alarm valve with main drain outlet and pressure gauges, 2" main drain, flow switch and fire department connection located in the designated Mechanical Rooms of each building.
b. Piping shall be concealed above ceilings where ceilings are present and may be run exposed in areas without ceilings.
c. Provide sprinkler heads below mechanical ducts and similar obstructions over 48" wide.
d. Provide sprinkler protection per NFPA 33 of Paint Booth 127A.
e. Provide a sidewall sprinkler head in the elevator shaft below the lowest point of elevator travel to protect the elevator pit.

1.8 SYSTEM DESIGN:

A. Design density and area of application.

1. Areas designated as Storage, Mechanical, Elevator Equipment, and similar areas: Ordinary Hazard Group 2, 0.20 gpm/sq ft over 3000 sq ft. with 500 gpm hose stream.

2. All other areas: Light Hazard, 0.10 gpm/sq ft over 3000 sq ft. with 250 gpm hose stream.

B. Maximum coverage per sprinkler head.

1. Ordinary Hazard: 130 sq ft.
2. Light Hazard: 225 sq ft.

C. The design area shall be the hydraulically most remote rectangular area having a dimension parallel to the branch line equal to, or greater than, 1.2 times the square root of the area of sprinkler operation.

D. Water supply at point of connection to 12" main under Geneva (to be used for hydraulic calculations):

Static Pressure:	xxx psi
Residual Pressure:	xxx psi
Flow:	xxxx gpm

1.9 WARRANTY:

A. Materials, equipment, and workmanship shall be free from defects for 12 months from the "Date Left in Service with All Control Valves Open," shown on "Contractor's Material and Test Certificate." If any Work is found to be defective, Contractor shall promptly, without cost to Owner, and in accordance with Owner's instructions, either correct such defective Work, or if it has been rejected by Owner, remove it from the site and replace it with non-defective Work. Submit two copies of Warranty Certificates to Architect.

1.10 REFERENCES:

A. NFPA (National Fire Protection Association) 13, "Installation of Sprinkler Systems," Current Edition.
B. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances", Current Edition.
D. IBC (International Building Code), 2003.
E. IFC (International Fire Code), 2003.
F. UFC (Unified Facilities Criteria
G. Underwriters Laboratories "Fire Protection Equipment Directory," Current Edition.
H. Factory Mutual Systems "Approval Guide," Current Edition.

PART II - PRODUCTS

2.1 Acceptable Manufacturers of sprinkler equipment, heads and devices.

A. Gem.
B. Reliable.
C. Star.
D. Viking.

2.2 PIPE:

A. Underground:

1. All underground piping to be approved for potable water use.

2. PVC, Class 150, AWWA C900.

3. Ductile iron, Class 50, AWWA C151.

a. All ductile iron pipe shall be encased within polyethylene per ANSI/AWWA C105/A21.5.

B. Interior:

1. All piping shall be steel schedule 40 and shall meet or exceed the following standards: ASTM A795, ANSI/ASTM A53, ASTM A135, ANSI B36-10M, UL CRR (Corrosion Resistance Rating) minimum 1.0 for threaded pipe.

2.3 FITTINGS:

A. Underground Piping:

1. Ductile iron or cast iron, AWWA C110.

B. Interior Piping:

1. Cast iron threaded, ANSI B16.4.

2. Cast iron flanged, ANSI B16.1.
3. Malleable iron threaded, ANSI B16.3.

4. Forged steel fittings, socket welded and threaded, ANSI B16.11.

5. Other types of fittings may be used, but only those investigated and listed for this service and approved by the project engineer.

6. Plain end couplings, saddle couplings, and clamp type couplings are not acceptable.

2.4 HANGERS:

A. Hangers shall conform to the minimum requirements of NFPA 13.

2.5 SEISMIC FITTINGS AND BRACES:

A. Earthquake bracing shall conform to the minimum requirements of NFPA 13.

2.6 SPRINKLER HEADS:

A. Areas without ceilings: Small frame pendent or upright, ordinary temperature, brass, glass bulb.

B. All other areas: Small frame, recessed, chrome plated, bulb type, ordinary temperature, white (2) piece adjustable canopy. Provide standard pendent sprinkler heads with deeper escutcheons where spray distribution of a recessed sprinkler head would be obstructed by ceiling mounted fixtures such as strip lights.

C. Provide dry pendent sprinkler heads in any walk-in coolers or freezers.

D. Sprinklers of intermediate and high temperature ratings shall be installed in specific locations as required by NFPA 13, 4-3.1.3.

E. One spare head of each type for spare head cabinet and one head wrench for each type sprinkler.

2.7 VALVES:

A. Riser:

1. Butterfly pattern system control valve with built-in tamper switch.

2. Alarm valve with main drain outlet and pressure gauges.

B. Fire Department Connection:

1. Swing pattern, grooved end check valve.

2.8 FIRE DEPARTMENT CONNECTION:

A. Provide a polished brass, 2-1/2" x 2-1/2" x 4" fire department connection with national standard threads, breakable caps with escutcheon labeled "Auto. Spkr.". Provide a 1/2" automatic ball drip with discharge to the outside.

2.9 ALARM DEVICES:

A. Riser:

1. Valve tamper switches: The valve tamper switches shall be SPDT electrical switches rated for 125 Vac for monitoring the position of control valves, UL listed, and FM approved. Switches shall be Potter Electric Signal, Model OSYSU-A or Engineer approved equal.
Note: Device is furnished and installed by fire sprinkler contractor and wired by fire alarm contractor.

2. Water flow switch: Furnish and install a water flow detector, designed for wet pipe sprinkler systems, listed by UL and approved by Factory Mutual. Detector shall be vane type for actuation of two SPDT switches rated for 125 Vac at water flows of 10 gpm or greater. Switch shall incorporate adjustable delay retard device which delays actuation of the switch caused by transient flow surges.
Note: Device is furnished and installed by fire sprinkler contractor and wired by fire alarm contractor.

B. Exterior:

1. Provide and install a 10" electric bell on the exterior of the building near the fire department connection. Device to be wired directly to flow switch by alarm contractor.

PART III - EXECUTION

3.1 INSPECTION:

A. Inspect job site prior to fabricating materials. Coordinate and sequence installation with the progress of other mechanical and structural systems and components.

3.2 INSTALLATION:

A Install system in compliance with methods detailed in NFPA 13, including seismic requirements for Area 1, maximum potential for earthquake damage.

B. Offset as needed for other trades. Avoid conflict in areas of tight construction. Run mains in beam and truss space where space between bottom of truss is insufficient. Do not obstruct access to air control boxes, access doors, lights or other ceiling mounted equipment.

C. Sprinkler heads shall be symmetrically located within the ceiling pattern.

D. Submit piping and equipment data sheets for review by the Architect/Engineer prior to start of the installation.

E. Close pipe openings with caps or plugs during installation. Cover and protect components of the system against dirt and chemical or mechanical injury.

F. Paint exposed piping for sprinkler system in accordance with requirements of Division 09000.

G. Provide concrete splash blocks for drains test valve discharge, etc. Concrete splash blocks shall be pre-fabricated, 2-1/2" thick, Amcor or Engineer approved equal.

H. Locate inspectors test valve at most hydraulically remote point of sprinkler system. Extend drain line and discharge to ground level, (concealed) Discharge to splash block. Where discharge is not visible from valve, install sight glass at valve to monitor flow.

I. Piping shall only be installed in areas where temperatures will not drop below 40^{o}F. If piping must be installed in unheated areas the piping must be fitted with an antifreeze loop and filled with an antifreeze solution per the requirements of NFPA 13.

J. Provide chrome escutcheons around exposed piping where piping passes through walls or ceilings in a finished area.

3.3 FIELD QUALITY CONTROL:

A. Obtain permits and post bonds as required by state and local AHJ's (Authorities Having Jurisdiction).

B. Inform AHJ's of job progress. Request presence of AHJ'S, perform tests, and document results using Contractor's Material and Test Certificates.

3.4 TESTING:

A. Hydrostatically test all system piping for two hours at 200 psi with no loss in pressure and no visible leakage. Conduct the testing after all of the fire sprinkler heads and piping are installed. Have the tests witnessed by the AHJ's and Engineer. Submit a Contractor's Material and Test Certificate to the Architect upon successful completion of the testing.

B. Train the Owner's maintenance personnel in the proper operation, testing and maintenance of all installed equipment.

C. Conduct an inspection and operational test (main drain and inspector's test) at the end of the one-year guarantee period. The inspection and testing shall be in accordance with manufacturer's recommendations and NFPA 25. A written report is to be sent to the Owner upon completion of the inspection. Fire sprinkler installer shall conduct the tests.

3.5 DISINFECTION:

A. Introduce dosage of 50 ppm chlorine in overhead piping. During the contact period open and close all system valves several times. At end of 24-hour retention period at least 10 ppm shall remain throughout the piping.

B. At end of retention period, flush system until residual chlorine is reduced to less than 1.0 ppm.

3.6 CLEANING:

A. Remove oil, scale, debris, and foreign substances from interior and exterior of devices, equipment, and materials prior to installation.

B. Upon job completion, remove tools, surplus materials and equipment, leaving all areas broom clean.

3.7 ACCEPTANCE:

A. Acceptance of installation is subject to final inspection and approval by:

1. Utah National Guard.
2. Utah State Fire Marshal's Office.
3. Architect or his representative.

3.8 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 210800, Commissioning of Fire Suppression. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 21 10 00

INDEX

DIVISION 22 - PLUMBING

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Section 220100 Operation and Maintenance of Plumbing
Section 220519 Meters and Gages for Plumbing Piping
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SECTION 220000 – GENERAL PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

Sections of other Divisions which relate to mechanical work apply to the work of this section. See various Sections on sitework, underfloor work, structural work, finish materials, etc.

B. RELATED SECTIONS: Refer to "Electrical Requirements for Plumbing Equipment Section in Division 22 for basic electrical requirements for all plumbing equipment. Special and specific electrical requirements are specified within each respective equipment specification section.

1.2 SUMMARY: This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 22 00 00. It expands and supplements the requirements of Division 01000.

This Division does not define, nor is it limited by, trade jurisdictions. All work described herein is a part of the General Contract and is required of the Contractor regardless.

1.3 DESCRIPTION OF PROJECT: The plumbing work described in these plumbing specifications is for a project located at the Camp Williams Utah National Guard, in Riverton, Utah. Altitude readings, unless otherwise noted, are for an elevation of 4,200 feet above sea level and adjustment to manufacturer's performance data shall be made accordingly.

1.4 CODES AND PERMITS, AUTHORITIES HAVING JURISDICTION:

A. The plumbing work shall be performed in strict accordance with the applicable provisions of the various codes, ordinances and adoptions pertaining to the project location in effect on the date of invitation for bids. All materials and labor necessary to comply with rules, regulations and ordinances shall be provided. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern.

B. The Contractor shall hold and save the Owner and Architect/Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

C. Permits necessary for the prosecution of the work under this contract shall be secured and paid for by the contractor(s) include connection fees related to utility hookups. Contractor shall include all sewer, storm drainage and water connection fees and shall verify current rate with Orem City prior to bid.

D. REFERENCE STANDARDS:

American Welding Society
International Mechanical Code with Utah State Amendments
International Building Code with Utah State Amendments
International Plumbing Code with Utah State Amendments
NFPA Codes
Local Fuel Utility Regulations
Local Power Utility Regulations
American Gas Association
ASME Codes for Pressure Vessels and Piping
ANSI B31.1 Piping
ANSI A117.1 Buildings and Facilities Accessible To and Usable by Physically Handicapped People.
ADA: Americans with Disability Act

E. Final inspection by the Architect/Engineer will not be made nor Certificate of Substantial Completion issued until certificates of acceptability from the Authorities having jurisdiction are delivered.

1.5 DEFINITION OF PLANS AND SPECIFICATIONS: The plumbing drawings show the general arrangement of piping, equipment, etc., and shall be followed as closely as the actual building construction and the work of other trades will permit. The architectural and structural drawings shall be considered as part of the work insofar as these drawings furnish the Contractor with information relating to design and construction of the building. Architectural drawings shall take precedence over plumbing drawings for actual locations, quantities, etc. of plumbing components. Request clarification and participate in resolution in the event of conflict.

Because of the small scale of the plumbing drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing such extensions, fittings, valves and accessories to meet the conditions as may be required. Some small scale work is not shown such as control conduit and piping, incidental piping, specialties. Provide as directed by note or specification.

Examine the actual construction site prior to bidding and obtain an understanding of the conditions under which the work will be performed. No allowances will be made for failure to make such examination.

During construction, verify the dimensions governing the plumbing work at the building. No extra compensation shall be claimed nor allowed because of differences between actual dimensions and those indicated on the drawings. Examine adjoining work on which plumbing work is dependent for perfect efficiency, and report any work of other trades which must be corrected. No waiver of responsibility for defective work shall be claimed nor allowed due to failure to report unfavorable conditions affecting the plumbing work.

1.6 ROUGH-IN:

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 50 for rough-in requirements.

1.7 PLUMBING INSTALLATIONS:

A. Coordinate plumbing equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for plumbing installations.

D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

E. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

F. Coordinate the cutting and patching of building components to accommodate installation of plumbing equipment and materials.

G. Where mounting heights are not detailed or dimensioned, install plumbing services and overhead equipment to provide the maximum headroom possible.

H. Install plumbing equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

I. Coordinate the installation of plumbing materials and equipment above ceilings with suspension system, ductwork, mechanical equipment, light fixtures, and other installations.

J. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

K. Where plumbing work penetrates other trade work such as gypsum board walls, etc., penetration shall be neatly cut and walls shall be filled and patched.

1.8 ACCESSIBILITY:

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

B. Extend all grease fittings to an accessible location.

C. Establish required clearance to all installation features involving operation and maintenance. Respect manufacturer’s recommendations for access and clearance.

D. Access Doors - General: All items of plumbing equipment which may require adjustment, maintenance, replacement or which control a system function shall be made readily accessible to personnel operating the building.

1. Provide access doors in floors, walls, ceiling and partitions to valves, cleanouts, chases, etc. Access doors shall be all-steel construction equivalent to "Milcor" by Inland Ryerson in a style approved by the Owner's Representative. Doors shall be 24" x 24", or as needed, with screwdriver latches.

1.9 CHANGE ORDERS: See General Conditions.

1.10 ALTERNATIVE CONSTRUCTION/SUBSTITUTION: These documents outline a way in which the Owner may be delivered a functional and reliable facility. Drawings and specifications describe reasonable engineering practice for the Contractor to follow.

Coordination between trades may result in periodic needs to adjust the installation from that indicated, but in no case shall the intended function be compromised.

The Contractor may perceive some work methods which differ from those specified which could save time and effort. These may be presented to the Architect with a breakdown of possible cost savings for review. Implement only with authorization.

Materials substitutions will generally be covered in a review process prior to bidding. After bidding, substitutions shall be proposed only on the basis of definitive cost accounting and implemented only with authorization.

1.11 CUTTING AND PATCHING:

A. Layout the project ahead of time, providing sleeves and blockouts and have work specifically formed, poured and framed to accommodate mechanical installations. Cut and patch only as needed.

B. Refer to the Division 1 Section: CUTTING AND PATCHING for general requirements for cutting and patching.

C. RECORD DRAWINGS: During the course of construction, maintain a set of drawings, specifications, change orders, shop drawings, addenda, etc., for reference and upon which all deviations from the original layout are recorded. These marked-up documents shall be turned over to the Architect/Engineer at the conclusion of the work so that the original tracings can be revised. If the Contractor fails to mark up the prints, he shall reimburse the Architect/Engineer for time required to do so.

D. Refer Specification Section: BASIC ELECTRICAL REQUIREMENTS for cutting and patching electrical equipment, components, and materials.

E. Do not endanger or damage installed Work through procedures and processes of cutting and patching.

F. Arrange for repairs required to restore other and any work damaged as a result of mechanical installations.

G. No additional compensation will be authorized for cutting and patching Work that is necessitated by ill-timed, defective, or non-conforming installations.

H. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work;

2. Remove and replace defective Work;

3. Remove and replace Work not conforming to requirements of the Contract Documents;

4. Remove samples of installed Work as specified for testing:

5. Install equipment and materials in existing structures.

I. Upon written instructions from the Architect/Engineer, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

J. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping and other mechanical items made obsolete by the new Work.

K. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

L. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

1.12 SUBMITTALS: Submittal of shop drawings, product data, and samples will be accepted only from the Contractor to the Architect. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed. The Contractor shall document each transmittal and shall sign and stamp the submittal indicating that it has been reviewed and is in compliance with the criteria of the project, any exceptions being clearly noted.

A. SHOP DRAWINGS: As soon as possible after the contract is awarded, submit to the Architect, seven (7) copies of the descriptive literature covering all equipment and materials to be used in the installation of mechanical systems for this project. Written confirmation of acceptable review by the Owner's Representative shall be obtained before ordering, purchasing, acquiring or installing any such equipment or materials for the project.

The submittals shall be prepared in an orderly manner after the order of this specification, contained in a three-ring looseleaf binder(s) with identification tabs for each item or group of related items. Submitted literature shall clearly indicate performance, quality, utility requirements, dimensions of size, connection points and other information pertinent to effective review.

Equipment must fit into the available space with allowance for operation, maintenance, etc. The Contractor shall take full responsibility for space and utility requirements for equipment installed.

Factory-wired equipment shall include shop drawings of all internal wiring to be furnished with unit.

Review of the Architect/Engineer is for general conformance of the submitted equipment of the project specification; in no way does such approval relieve Contractor of his obligation to furnish equipment and materials that comply in detail to the specification, nor does it relieve the Contractor of his obligation to determine actual field dimensions and conditions which may affect his work.

1.13 OPERATION AND MAINTENANCE TRAINING:

A. Instruction Of Owner's Personnel: At a time prior to Owner making use of a device or system, and in general after testing and balance work for a building or major system is complete, prepare, schedule and conduct a series of training sessions for Owner's operating and supervisory personnel. Instructions shall cover each device and system with emphasis on understanding of the purpose and function, the maintenance requirements and the proper adjustment and operating technique.

B. Instruct building operating staff in operation and maintenance of mechanical systems utilizing Operation and Maintenance Manual when so doing.

C. Minimum instruction periods shall be as follows:

1. Plumbing - XXXX hours, each of xx days, (x hours total).

D. Conduct initial instruction periods after pre-final inspection when systems are properly working and before final payment is made. Schedule subsequent visits throughout the first year.

E. None of these instructional periods shall overlap another.

F. Vendors for each piece of equipment controls, etc., shall participate along with the Contractor(s).

1.14 GUARANTEE/WARRANTY: The following guarantee is a part of this specification and shall be binding on the part of the Contractor and his assigns:

"Contractor guarantees that this installation is in accordance with the terms of the Contract and is free from mechanical defects. He agrees to replace or repair, to the satisfaction of the Owner's Representative, any part of this installation which may fail or be determined unacceptable within a period of one (1) year after final acceptance. See also the General Conditions of these specifications. Failed equipment in the repair or replacement shall be guaranteed for one full year from the date of recommission."

Compile and assemble the warranties required by Division 15 into a separated set of vinyl covered, insert sheets, tabulated and indexed for each reference, included in the O & M Manual.

Provide complete warranty information for each item to include product or equipment to include data of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

Mechanical systems and equipment shall not be considered for substantial completion and initiation of warranty until they have performed in service continuously without malfunction for at least thirty (30) working days.

1.15 TESTS AND CERTIFICATIONS: Make all tests required by code or specification in the presence of a representative of the Owner, recorded and certified by the Contractor and Representative. Involve local authorities where required.

1.16 PERMITS, FEES, LICENSES: Pay for all permits, fees and licenses required for the conduct of the specified work and be responsible for all criteria associated with the same. Comply with requirements for inspection, certifications, etc.

1.17 CEILING SPACE COORDINATION: Carefully coordinate ceiling cavity space with all trades; however, installation of plumbing equipment within the ceiling cavity space allocation, in the event of conflict, shall be in the following order: plumbing waste lines; supply, return and exhaust ductwork; domestic hot and cold water; fire protection; control conduit.

PART 2 - GENERAL MECHANICAL MATERIALS AND METHODS

2.1 QUALITY OF MATERIALS AND EQUIPMENT:

A. All equipment and materials shall be new, and shall be the standard products of manufacturers regularly engaged in the production of plumbing, heating, ventilating and air conditioning equipment, and shall be the manufacturer's latest design. Specific equipment shown in schedules on drawings and specified herein is to be the basis for the Contractor's bid. Provisions for substitute equipment are outlined in the General Conditions. All materials shall be produced by manufacturing plants located in the United States of America.

B. Furnish and install all major items of equipment specified in the equipment schedules on the drawings complete with all accessories normally supplied with catalog items listed, and all other accessories necessary for a complete and satisfactory installation.

2.2 PROTECTION OF MATERIALS AND EQUIPMENT:

A. Close pipe and duct openings with caps or plugs to prevent lodgement of dirt or trash during the course of installation. Cover equipment tightly and protect against dirt, water and chemical or mechanical injury. Plumbing fixtures intended for the final installation shall not be used by the construction forces. At the completion of the work, clean fixtures, equipment and materials and polish thoroughly and deliver in a factory dock condition for the Owner's acceptance. Make damage and defects developing before acceptance of the work good at Contractor's expense.

B. Do not make temporary use of project equipment, new or existing, during construction without the consent of Utah Valley State College Physical Plant. DO NOT USE SYSTEM FOR TEMPORARY HEAT!!

2.3 QUALIFICATIONS OF WORKMEN:

A. All mechanics shall be capable journeymen, skilled in the work assigned to them. Apprentices may be used with appropriate direction.

B. Employ no unskilled persons in the work which he is given to do; execute all work in a skillful and workmanlike manner. All persons employed upon this work shall be competent, faithful, orderly and satisfactory to the Owner. Should the Owner's Representative deem anyone employed on the work incompetent or unfit for his duties, and so certify, Contractor shall dismiss him and he shall not be again employed upon the work without permission of the Owner's Representative.

C. All welders involved in welding of pressure piping systems shall be certified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. Written verification of successful test completion shall be submitted to Architect prior to initiating work.

2.4 FOREMAN: Designate a general mechanical foreman to the Owner's Representative to be consistently available on site for consultation. Do not replace this individual without prior approval from the Owner's Representative.

2.5 USE OF COMMON VENDORS: Regardless of subcontract delegations, coordinate purchasing between trades so that equipment and materials of similar nature come from a single vendor, i.e., all package HVAC units shall be common source. Valves, etc., the same. Do not burden the Owner with multiple brands of similar equipment unless so directed.

2.6 ROOF/WALL/FLOOR PENETRATIONS - FLASHINGS:

A. Sleeves through the floor into dry rooms shall be flush with the floor, caulked and sealed.

B. Pipe sleeves shall allow for movement of the pipe due to expansion and contraction, yet to include seismic restraint.

C. Refer to Section for fire stopping requirements.

D. FLASHINGS:

1. Flash all pipes and ducts penetrating the roof. Vent pipes terminating within 24" of the roof shall have a seamless flashing of 6-pound lead clamped to the pipe, and with a flashing shield extended horizontally not less than 12" all around. For single ply membrane roof, follow manufacturer's directions, provide required flashing components.

2. For built-up and gravel roof, clamp roof drains to a 6-pound lead flashing extending 18" all around. For single ply membrane roof, follow manufacturer's directions.

3. Other piping penetrating the roof shall be flashed and counterflashed. See drawings or Architect/Engineer for additional detail.

4. Make all ductwork penetrating the roof watertight with flashings, counterflashing and sealant. Provide curbs for all such openings.

2.7 EXCAVATING AND BACKFILLING (GENERAL):

A. Provide all excavation, trenching and backfilling for Division 22 00 00 underground piping work. Excavation and backfilling shall comply with applicable paragraphs of Division 2. Tamp bottoms of trenches hard and, for soil and waste piping, grade to secure uniform fall of 1/4" per foot, or as noted. Excavate bell holes for hub and spigot pipes so that pipe rests on solid ground for its entire length. Lay sewer and water pipe in separate trenches, except where otherwise noted, as detailed.

B. After work has been tested, inspected and approved by the Owner's Representative and/or State/Local Inspector, and prior to backfilling, clean the excavation of all rubbish, and clean backfill materials free of trash. Backfill shall be placed in horizontal layers not exceeding 12" in thickness, properly moistened. Mechanically compact each layer with suitable equipment to a dry density of not less than 95 percent as determined by the Modified AASHO Test T-18O. See Division 2 for additional requirements.

1. Provide adequate shoring to safeguard workers from cave-ins for all excavations.

2. In areas where General Contractor has finish grade work to do, Mechanical Contractor shall backfill and compact to 8" below finish grade. Where no finish surface work is to be done, Mechanical Contractor shall backfill and compact to and match adjacent undisturbed surface with allowance for settling, etc.

3. Protect from damage all existing underground utilities or utility tunnels indicated on the contract drawings (or field located for the Contractor by the Owner prior to excavation operations). Any damage to identified existing utilities or utility tunnels shall be repaired by the Contractor at no cost to the Owner.

2.8 HANGERS AND SUPPORTS (GENERAL):

A. Provide hangers and/or supports for all equipment, piping and ductwork. Primary information is contained in these specifications and on the drawings.

B. Provide hangers and supports to correlate with seismic restraint and vibration isolation.

2.9 MANUFACTURER'S DIRECTIONS: Install all equipment in strict accordance with all directions and recommendations furnished by the manufacturer. Where such directions are in conflict with the plans and specifications, report such conflicts to the Architect, who shall direct adjustments as he deems necessary and desirable.

2.10 LUBRICATION: Lubricate equipment at startup. Then, provide all lubricants for the operation of all equipment until acceptance by the Owner. The Contractor is held responsible for all damage to bearings while the equipment is being operated by him.

2.11 ELECTRICAL WIRING AND CONTROL:

A. Motor starters, related motor starter equipment and power wiring indicated on the electrical drawings and control diagrams shall be furnished and installed under Division 16000 of this Specification. Items of electrical control equipment specifically mentioned to be furnished by the Division 15000 either in these specifications or on the electrical or mechanical drawings, shall be furnished and mounted by this Contractor and shall be connected under and as required by this Division 15000 and Division 16000 of these specifications.

B. Refer to the control equipment and wiring shown on the diagrams. Any changes or additions required by specific equipment furnished shall be the complete responsibility of the contractor.

C. Division must be fully coordinated with Division XXXXX to insure that all required components of the work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of coordination.

D. Where the detailed electrical work is not shown on the electrical drawings, the Mechanical Contractor shall furnish, install and wire or have prewired all specified and necessary controls for package air conditioning units and other equipment specified for this project. The objective of this paragraph is to make sure a complete operating system is obtained at no additional cost to the Owner for field wiring required related to the equipment.

2.12 FLUSHING AND DRAINING OF SYSTEMS/CLEANING OF PIPING: Fill, clean and flush and sterilize where appropriate, all water piping systems with water and drain these systems before they are placed in operation. Blow out all other piping systems with compressed air or nitrogen to remove foreign materials that may have been left or deposited in the piping system during its erection.

2.13 ARCHITECTURAL ACCESS DOORS:

A. Extent of Work: Provide architectural grade access doors at each point of required access to piping valves, and specialties, concealed equipment, etc. Coordinate this work with other sections for ceilings, walls, etc.

B. Material: Steel framed doors with heavy duty hinges and latch type locking mechanisms with surface finish configuration to accept, match or correlate with adjacent surface.

Product equivalent to Inland-Ryerson “Milcor”.

C. Installation: Complete, blended into adjacent work.

2.14 JOBSITE CLEANUP:

A. Keep site clean during progress of work.

B. At the conclusion of work, clean all installation thoroughly.

1. Leave equipment in a factory dock condition. Correct any damage and touch up or repaint if necessary.

2. Remove all debris from site.

PART 3 – EXECUTION

3.01 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220000

SECTION 220100 - OPERATION AND MAINTENANCE OF PLUMBING

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specifications sections, apply to work of this section.

B. Division-22 Plumbing sections apply to work of this section.

1.2 SUMMARY:

A. Furnish two sets of bound operation and maintenance manuals. Manuals shall contain descriptive drawings and data which identify equipment installed at the project and detail the procedures and parts required to maintain and repair the equipment. Copies of approved submittals shall be included for all equipment.

1.3 OPERATION AND MAINTENANCE MANUAL FOR PLUMBING SYSTEMS:

A. General:

1. The "Operating and Maintenance Manual" is a bound compilation of drawings and data that the owner requires for each building or project. These manuals, complete with drawings and data, shall be furnished to the College Physical Plant.

2. The plumbing contractor has overall responsibility to obtain the necessary data from and compile the data as set forth in this specification, including items or equipment purchased by the Owner and delivered to the contractor for installation.

3. The number of binders (or "volumes") required for each individual building or project will depend on the amount of information to be catalogued.

4. All information included shall be legible and sufficiently marked to indicate the exact size, model, type, etc., of equipment furnished and installed.

B. Purpose: The Operating and Maintenance Manual is prepared to provide a ready reference to all important pieces of plumbing and electrical equipment installed on the project. It is also to provide the necessary operating and maintenance data for use by service personnel. It is also to provide information required for checking equipment performance or for planning of plant expansion or redesign.

PART II - MATERIALS AND METHODS

2.1 PAGE SIZE: All pages shall be standard 8-1/2 x 11 inches size or approximate multiples (preferably 16 x 11 inches) folded to 8-1/2 x 11 inch manilla pockets, which shall have standard three-ring side punching for insertion in the binders. The equipment name, drawing description and number shall be written on the face of each manilla pocket.

2.2 DRAWINGS: All drawings larger than 8-1/2" x 11" shall be folded and inserted in individual 8-1/2" x 11" manilla pockets, which shall have standard three-ring side punching for insertion in the binders. The equipment name, drawing description and number shall be written on the face of each manilla pocket.

2.3 BINDERS: Binders shall be Buckram binders with block lettering for sheet size 8-1/2 x 11 inches with 2" to 3-1/2" expandable metal capacity as required for the project. The number of binders, however, shall be based on not filling them beyond 4".

A. The following information shall appear on the front cover and backbone:

1. "Operation and Maintenance Manual".
2. Project Name (and volume number if more than one volume).
3. Project Number (seven digit University number).
4. Building name and number.
5. “Utah National Guard”.
6. Architect's name.
7. Engineer's name.
8. General Contractor's name.
9. Plumbing Contractor's name.
10. Items E through H need not be printed on the backbone.

2.4 CONTENTS AND INDEXING:

A. Manuals shall contain descriptions of the building systems in sufficient detail to adequately indicate the type of systems installed and the basic details of their operation.

B. All purchased equipment data shall be used to designate the sections. Within each section additional indexing of component parts may be required.

C. Operation and Maintenance Manuals shall contain to the fullest extent all possible information pertinent to the equipment. The arrangement and type of information to be filed shall be as follows:

1. Copy of purchase order with changes (if any).

2. Outline drawings, special construction details, "as built" electrical wiring and control diagrams for all major and supplementary systems.

3. Manufacturer's test or calculated performance data and certified test curves.

4. Installation, operating, and maintenance instructions, including a complete parts list and sectional drawing with parts identification numbers. Mark with model, size and plan number.

5. Manufacturer's brochure marked to indicate exact equipment purchased. Brochures on component parts supplied by a manufacturer with his equipment, but not manufactured directly by him, shall also be included.

6. The serial numbers of each item of equipment installed are to be listed with the model numbers and plan symbols.

7. Include a Table of Contents. The contents shall be divided with tabbed index dividers into the following suggested parts:

a.	Part I	Building and System Descriptions
b.	Part II	Purchased Equipment Data
c.	Part III	Test Reports and Valve Charts
d.	Part IV	Preventative Maintenance Recommendations

8. A copy of the approved submittals for each piece of equipment.

9. A copy of all testing, adjusting and balancing reports.

10. Wiring diagrams, marked with model and size and plan symbol.

11. Operating and Maintenance Manuals data for Part I shall be obtained directly from the plumbing and electrical consultants. (Allow consultant preparation cost.)

12. The index shall contain the name and address of the manufacturer and, if different, where replacement and repair parts may be obtained.

END OF SECTION 220100

SECTION 220519 – METERS AND GAGES FOR PLUMBING PIPING

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. This section is Division-22 Plumbing section, and is part of each Division-22 section making reference to meters and gages specified herein.

1.2 SUMMARY

A. Extent of meters and gages required by this section is indicated on drawings and/or specified in this and other Division-22 sections.

B. Meters and gages specified in this section include the following:

1. Temperature Gages and Fittings.

a. Glass Thermometers.
b. Thermometer Wells.
c. Temperature Gage Connector Plugs.
d. Digital Thermometers

2. Pressure Gages and Fittings.

a. Pressure Gages.
b. Pressure Gage Valves.
c. Pressure Gage Connector Plugs.

C. Meters and gages furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-22 sections.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of meters and gages, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings and calibrated performance curves, certified where indicated. Submit meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 1.

1.5 REFERENCES:

A. Codes And Standards:

1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

PART II - PRODUCTS

2.1 GLASS THERMOMETERS:

A. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Case: Die cast aluminum finished in baked epoxy enamel or extruded brass, glass front, spring secured, 9" long. Separable socket (union type).

C. Adjustable Joint: Die cast aluminum, finished to match case, 180 degrees adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device. Stainless steel bulb chamber.

D. Tube And Capillary: Stainless steel bulb chamber. Mercury filled, magnifying lens, 1% scale range accuracy, shock mounted.

E. Scale: Satin faced, non-reflective aluminum, permanently etched markings.

F. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.

G. Range: Conform to the following:

1. Hot Water: 30^{o} - 240^{o}F with 2^{o}F scale divisions.
2. Cold Water: 0^{o} - 100^{o}F with 2^{o}F scale divisions.

H. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:

1. Marshalltown Instruments, Inc.
2. Marsh
3. Trerice (H.O.) Co.
4. Weksler
5. Weiss Instruments, Inc.
6. U.S. Gauge

2.2 THERMOMETER WELLS:

A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

B. Manufacturer: Same as thermometers.

2.3 TEMPERATURE/PRESSURE GAGE CONNECTOR PLUGS:

A. General: Provide temperature gauge connector plugs pressure rated for 500 psi and 200 degrees F (93 degrees C). Construct of brass and finish in nickel-plate, equip with 1/2" NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

B. Manufacturer: Subject to compliance with requirements, provide temperature gauge connector plugs of one of the following:

Peterson Equipment Co., SISCO, Universal.

2.4 PRESSURE GAGES:

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.

C. Case: Drawn steel or brass or phenolic, glass lens, 4-1/2" diameter.

D. Connector: Brass with 1/4" male NPT.

E. Scale: White coated aluminum, with permanently etched markings.

F. Range: Conform to the following; place operating pressure in mid-range.

1. Water: 0 - 100 psi - 160 psi, as needed.

G. Manufacturer: Subject to compliance with requirements, provide pressure gauges of one of the following:

1. U.S. Gauge
2. Marsh Instrument Co.
3. Marshalltown.
4. Trerice.
5. Weiss.
6. Weksler.

2.5 PRESSURE GAGE VALVES:

A. General: Provide pressure gauge valves between pressure gauges and gauge tees on piping systems. Construct gauge valve of brass bar stock with 1/4" female NPT on each end, and knurled handle brass plug or use 1/4" ball valve or Crane 88 needle valve (for steam).

B. Manufacturer: Same as for pressure gauges.

PART III - EXECUTION

3.1 INSPECTION: Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF TEMPERATURE GAUGES:

A. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.

B. Locations: Install in the following locations, and elsewhere as indicated:

1. At inlet and outlet of each hydronic zone.

2. At inlet and outlet of each hydronic coil in air handling units.

3. At inlet and outlet of each boiler.

C. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

D. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.3 INSTALLATION OF PRESSURE GAGES:

A. General: Install pressure gages in piping tee with pressure gage bar stock valve located on pipe at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated:

1. At suction and discharge of each pump, single gage, mani-folded to include inlet strainer.

2. Across each pressure reducing valve.

3. At water service connection to domestic cold water.

4. At inlet and outlet of strainer.

C. Pressure Gage Valves: Install in piping tee with snubber for water.

D. Pressure Gage Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220519

SECTION 220523 – GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. This section is Division-22 Plumbing section, and is part of each Division-22 section making reference to valves specified herein.

1.2 SUMMARY:

A. Extent of valves required by this section is indicated on drawings and/or specified in other Division-22 sections.

B. Types of valves specified in section include the following:

1. Gate Valves.
2. Drain Valves.
3. Ball Valves.
4. Butterfly Valves.
5. Check Valves.

C. Valves furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-22 sections.

1.3 QUALITY ASSURANCE:

A. MANUFACTURER'S QUALIFICATIONS: Firms regularly engaged in manufacture of valves, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years. Crane, Powell, Nibco/Scott, Lunkenheimer, Stockholm, Appollo, Watts.

B. VALVE TYPES: Provide valves of same type by same manufacturer.

C. VALVE IDENTIFICATION: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on valve body.

1.4 SUBMITTALS:

A. PRODUCT DATA: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing Manufacturer's figure number, size, location, and valve features for each required valve.

B. SHOP DRAWINGS: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. MAINTENANCE DATA: Submit maintenance data and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual; in accordance with requirements of Division 1.

1.5 REFERENCES:

A. CODES AND STANDARDS:

1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".
3. UL and FM Compliance: Provide valves used in fire protection piping, which are UL-listed and FM approved.

PART II - PRODUCTS

2.1 VALVES:

A. GENERAL: Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

B. SIZES: Unless otherwise indicated, provide valves of same size as upstream pipe size.

C. OPERATORS: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 5" and smaller, other than plug valves. Provide one wrench for every 10 plug valves. Provide gear operators for quarter-turn valves 6" and larger. Provide chain-operated sheaves and chains for overhead valves 4" and larger over 8'-0" AFF.

D. CONNECTIONS: Unless otherwise noted for a particular reason, any valve 2" and larger shall have flanges.

2.2 MANUFACTURERS: Unless listed otherwise subject to compliance with requirements, provide valves of one of the following:

A. Crane
B. Keystone
C. Powell
D. Nibco/Scott
E. Lunkenheimer
F. Stockham
G. Milwaukee

All valves of the same type shall be of the same manufacturer.

2.3 DOMESTIC COLD WATER, DOMESTIC HOT WATER, DOMESTIC HOT WATER RETURN (COPPER PIPE):

A. BALL VALVES:

1. 3" and Smaller: 125 psig WOG @ 220^{o}F, bronze construction, threaded ends, bubble tight teflon seat at 100 psig under water, hard, stainless steel ball. Operate with flow in either direction. Suitable for throttling and tight shut-off. Watts B-6000, B-6001.

B. BUTTERFLY VALVES:

1. For piping 4" and larger. Install with weld neck flanges, Norris Series R-3011-23SS-2B, double tapped lug, single-flange ductile iron or cast iron body, 316 SS disc, stainless steel shaft with extended neck for insulated pipe, EPDM seat and O-rings, indicating worm gear operator, 175 psig bubble tight pressure rating (250 where required). Centerline, Demco, Keystone, Rockwell, Grinnell, or Milwaukee. No other Manufacturer’s approved.

C. SWING CHECK VALVES:

1. 2" and Smaller: Crane No. 37 bronze, threaded, Y-pattern, 200# WOG at swing check valve.

2. 2-1/2" and Larger: Crane No. 373, iron body, flanged, 200# WOG swing check valve with bronze trim.

D. BALANCING VALVES: Bell and Gossett circuit setter plus or Armstrong CB circuit balancing valve with pressure taps or Flowset. Gate valves, Ball valves or butterfly valves may not be used as balancing valves. Provide schedule showing pressure drop and flow rate of each valve.

2.4 MISCELLANEOUS VALVES AND SPECIALTIES:

A. GAUGE VALVES: Crane #88 bronze needle valve or Trerice barstock needle valve, or ball valve.

PART III - INSTALLATION

3.1 VALVE INSTALLATION:

A. Locate all valves in locations which will allow easy operation and facilitates maintenance.

B. Install valves with stems on horizontal or above.

C. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

D. All branch lines which supply a specific area of the building (such as a toilet room or kitchen) shall be valved near the main so that each area may be isolated from the system for repairs without having to shut down both men and women's restrooms, other labs, or the whole building.

E. All valves located above a non-lay-in type ceiling or behind a wall shall be made accessible by means of an access door.

3.2 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220523

SECTION 220529 – HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. This section is Division-22 Plumbing section, and is part of each Division-22 section making reference to supports and anchors specified herein.

1.2 SUMMARY:

A. Extent of supports and anchors required by this section is indicated on drawings and/or specified in other Division-22 sections.

B. Types of supports and anchors specified in this section include the following:

1. Horizontal-Piping Hangers and Supports.
2. Vertical-Piping Clamps.
3. Hanger-Rod Attachments.
4. Building Attachments.
5. Saddles and Shields.
6. Miscellaneous Materials.
7. Roof Equipment Supports.
8. Anchors.
9. Equipment Supports.

C. Supports and anchors furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-15 sections.

D. Relate this section to Section 22 05 48 regarding seismic and vibration control.

1.3 QUALITY ASSURANCE:

A. MANUFACTURER'S QUALIFICATIONS: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. PRODUCT DATA: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor.

B. SHOP DRAWINGS:

1. Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. MAINTENANCE DATA: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.5 REFERENCES:

A. CODES AND STANDARDS:

1. Code Compliance: Comply with applicable building, mechanical and plumbing codes pertaining to product materials and installation of supports and anchors.

2. UL and FM Compliance: Provide products which are UL-listed and FM approved.

3. MSS Standard Compliance:

   a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

   b. Select and apply pipe hangers and supports, complying with MSS SP-69.

   c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.

   d. Terminology used in this section is defined in MSS SP-90.

PART II - PRODUCTS

2.1 HORIZONTAL-PIPING HANGERS AND SUPPORTS:

A. GENERAL: Except as otherwise indicated, provide factory- fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.

B. ADJUSTABLE STEEL CLEVISES HANGERS: MSS Type 1. (For suspension of non-insulated or insulated stationary pipe lines; 1/2" to 30".)

C. STEEL DOUBLE BOLT PIPE CLAMPS: MSS Type 3. (For suspension of pipe requiring up to 4" of insulation and where flexibility of clamp is desirable; 3/4" to 24".)

D. STEEL PIPE CLAMPS: MSS Type 4. (For suspension of cold pipe lines or hot lines where little or no insulation is required; 1/2" to 24".)

E. PIPE HANGERS: MSS Type 5. (For suspension of piping when off-center closure allowing installation of hanger before erection of piping is desired; 1/2" to 4".)

F. ADJUSTABLE SWIVEL PIPE RINGS: MSS Type 6. (For suspension of non-insulated stationary pipe lines; 3/4" to 8".)

G. ADJUSTABLE STEEL BAND HANGERS: MSS Type 7. (For suspension of non-insulated stationary pipe lines; 3/4" to 8".)

H. ADJUSTABLE BAND HANGERS: MSS Type 9. (For suspension of non-insulated stationary pipe liens; 1/2" to 8".)

I. ADJUSTABLE SWIVEL RINGS, BAND TYPE: MSS Type 10. (For suspension of non-insulated stationary pipe lines; 3/8" to 8".)

J. SPLIT PIPE RINGS: MSS Type 11. (For suspension of non-insulated stationary pipe lines; 3/8" to 3".)

K. EXTENSION SPLIT PIPE CLAMPS: MSS Type 12. (For suspension of non-insulated stationary pipe lines; 3/8" to 3".)

L. U-BOLTS: MSS Type 24. (For support of heavy loads; 1/2" to 30".)

M. CLIPS: MSS Type 26. (For support of uninsulated piping not subject to expansion or contraction.)

N. PIPE SADDLE SUPPORTS: MSS Type 36, including steel pipe base- support and cast-iron floor flange. (To support pipe from floor stanchion, using floor flange to secure stanchion to floor 4" to 36".)

O. PIPE STANCHION SADDLES: MSS Type 37, including steel pipe base support and cast-iron floor flange. (To Type 36 except U-bolt provided for retaining pipe.)

2.3 VERTICAL-PIPING CLAMPS:

A. GENERAL: Except as otherwise indicated, provide factory- fabricated vertical-piping clamps complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.

B. TWO-BOLT RISER CLAMPS: MSS Type 8. (For support and steadying of pipe risers; 3/4" to 20". Also supports pipe covering or insulation.)

C. FOUR-BOLT RISER CLAMPS: MSS Type 42. (When longer ends are required for riser clamps.)

2.4 HANGER-ROD ATTACHMENTS:

A. GENERAL: Except as otherwise indicated, provide factory- fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.

B. STEEL TURNBUCKLES: MSS Type 13. (For adjustment up to 6" for heavy loads.)

C. STEEL CLEVISES: MSS Type 14. (For use on high temperature piping installations.)

D. SWIVEL TURNBUCKLES: MSS Type 15. (For use with split pipe rings, MSS type 11.)

E. MALLEABLE IRON SOCKETS: MSS Type 16. (For attaching hanger rod to various types of building attachments.)

2.5 BUILDING ATTACHMENTS:

A. GENERAL: Except as otherwise indicated, provide factory- fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.

B. CONCRETE INSERTS: MSS Type 18. (For upper attachment for suspending pipe hangers from concrete ceiling.)

C. TOP BEAM C-CLAMP: MSS Type 19. (Use under roof installations with bar joist construction, for attachment to top flange of structural shape.)

D. SIDE BEAM OR CHANNEL CLAMPS: MSS Type 20. (For attachment to bottom flange of beams, channels, or angles.)

E. CENTER BEAM CLAMPS: MSS Type 21. (For attachment to center of bottom flange

of beams)

F. WELDED BEAM ATTACHMENTS: MSS Type 22. (For attachment to bottom of beams where loads are considerable and rod sizes are large.)

G. C-CLAMPS: MS Type 23. (For attachment to structural shapes.)

H. TOP BEAM CLAMPS: MSS Type 25. (For attachment to top of beams when hanger rod is required tangent to edge of flange.)

I. SIDE BEAM CLAMPS: MSS Type 27. (For attachment to bottom of steel I-beams.)

J. STEEL BEAM CLAMPS W/EYE NUT: MSS Type 28. (Same as Type 28 with link extensions.)

K. LINKED STEEL CLAMPS W/EYE NUT: MSS Type 29. (Same as Type 28 with link extensions.)

L. MALLEABLE BEAM CLAMPS: MSS Type 30. (For attachment to structural steel.)

M. STEEL BRACKETS: One of the following for indicated loading:

1. Light Duty: MSS Type 31, to 570 pounds.

2. Medium Duty: MSS Type 32, to 1,500 pounds.

3. Heavy Duty: MSS Type 33, to 3,000 pounds.

N. SIDE BEAM BRACKETS: MSS Type 34. (For use on sides of steel or wooden beams.)

O. PLATE LUGS: MSS Type 57. (For attachment to steel beams where flexibility at the beam is desired.)

P. HORIZONTAL TRAVELERS: MSS Type 58. (For supporting piping systems subject to linear horizontal movements where head room is limited.

2.6 SADDLES AND SHIELDS:

A. GENERAL: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

B. PROTECTION SADDLES: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.

C. PROTECTION SHIELDS: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.

D. THERMAL HANGER SHIELDS: Constructed of 360 degrees insert of high density, 100 psi, water-proofed calcium silicate, encased in 360 degrees sheet metal shield. Provide assembly of same thickness as adjoining insulation.

E. MANUFACTURER: Subject to compliance with requirements, provide thermal hanger shields of one of the following:

1. Elcen Metal Products Co.
2. Pipe Shields, Inc.

2.7 MANUFACTURERS OF HANGERS AND SUPPORTS:

A. MANUFACTURER: Subject to compliance with requirements, provide hangers and supports of one of the following:

1. Kin-Line, Inc.
2. Fee & Mason Mfg. Co.; Div. Figgie International

3. ITT Grinnel Corp.
4. B-Line.

2.8 HIGH HUMIDITY AREAS: Use cadmium plated or galvanized hangers, attachments, rods, nuts, bolts and other accessories in boiler rooms or other high humidity areas.

2.9 MISCELLANEOUS MATERIALS:

A. METAL FRAMING: Provide products complying with NEMA STD ML 1.

B. STEEL PLATES, SHAPES AND BARS: Provide products complying with ASTM A 36.

C. CEMENT GROUT: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration. Use Embeco grout for non-shrink applications.

D. HEAVY DUTY STEEL TRAPEZES: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

E. PIPE GUIDES: Provide factory-fabricated guides, of cast semi- steel or heavy fabricated steel, consisting of bolted two- section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION:

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:

A. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through the openings at the tops of inserts.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:

A. GENERAL: Install hangers, supports, clamps and attachments to rigidly support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

C. Prevent electrolysis in support of copper tubing by the use of hangers and supports which are copper plated, or by isolating with foam rubber covering.

D. PROVISIONS FOR MOVEMENT:

E. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

F. Install supports within 2 feet of non-vertical flex connectors.

G. LOAD DISTRIBUTION: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

H. PIPE SLOPES: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.

I. INSULATED PIPING: Hangers shall not come in contact with pipe where pipe is specified to be insulated.

J. CLAMPS: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

K. SHIELDS: Where low-compressive-strength insulation or vapor barriers are indicated on cold or chilled water piping, install galvanized steel protective shields. Install calcium silicate blocks (12" long minimum) at support points.

L. SADDLES: Where insulation without vapor barrier is indicated, install protection saddles.

3.5 INSTALLATION OF ANCHORS:

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer for loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.

D. ANCHOR SPACINGS: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.6 EQUIPMENT SUPPORTS:

A. Provide concrete housekeeping bases for all floor mounted equipment including equipment on support stands furnished as part of the work of Division 15. Size bases to extend a minimum of 4" beyond equipment base in any direction, and 4" above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.

B. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

C. Furnish roof equipment supports to Contractor for installation as part of work of Division 7; not work of this section.

3.7 ADJUSTING AND CLEANING:

A. HANGER ADJUSTMENT: Adjust hangers so as to distribute loads equally on attachments.

B. SUPPORT ADJUSTMENT: Provide grout under supports so as to bring piping and equipment to proper level and elevations.

C. CLEANING: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.8 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROL FOR PLUMBING PIPING AND EQUIPMENT

PART I - GENERAL:

1.1 RELATED DOCUMENTS: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

This section is Division-15 Basic Mechanical Materials and Methods section, and is part of each Division-15 section making reference to pipes and pipe fittings specified herein.

1.2 SUMMARY: Furnish and install complete seismic restraint and vibration control systems for all work installed under Division 15. Work to be responsive to the intent of the Uniform Building Code, latest adopted edition for the respective seismic zone.

1.3 QUALITY ASSURANCE:

A. MANUFACTURERS QUALIFICATIONS: Engage the services of an independent seismic and vibration control subcontractor who shall have the technology, the experience, computer capabilities and manufactured products to prepare the required computations, shop drawings and special devices to meet the minimum requirements described herein.

The seismic and vibration control subcontractor shall visit the site during construction at a minimum of two specific periods.

1. When equipment is set in place, prior to placement of seismic restraint devices for the purposes of directing the contractor in properly locating and installing the approved devices.

2. At the completion of the project, prior to final mechanical inspection, for the purpose of verifying the correctness of the seismic restraint and vibration isolation device installation and preparing certification of the seismic vibration-isolation work.

The seismic subcontractor shall exercise the quality control for this work and shall include, but not be limited to instructions direct to the Mechanical (Division 15) Contractor concerning:

Anchoring of equipment.

Vibration mounting of equipment.

Equipment base coordination with restraint requirements.

Snubbing of equipment.

Bracing and anchoring of ductwork piping and conduit.

Provision for expansion and vibration of piping.

Concrete and/or steel pads or bases to assure proper mounting of restraints and isolators.

Vibration isolation of pumps, convertor, chiller, exhaust fans, supply air fans, relief fans, etc.

The subcontractor shall be responsible for identifying the need for the size and location of steel sole plates and their attachment to structural steel or concrete.

The subcontractor shall certify in writing that he has inspected the installation and that all isolation, anchors and seismic restraint materials are installed correctly and functioning properly. Certification shall be provided after all corrective work has been completed.

1.4 SUBMITTALS: Submittal data is required and shall consist of computations, vibration isolation selection, equipment anchors, anchor bolt sizes, supports, seismic restraints, sole plate data, restraint locations and type of restraints.

Submittal data shall identify dimensions, load deflection data, center of gravity, standard connections, manufacturer's recommendations, behavior problems including vibrations, thermal expansion, building expansion joints, etc., associated with equipment, ductwork, piping and conduit.

Calculations need not be submitted when restraint devices for piping, conduit and ductwork are proposed in accordance with the SMACNA Guidelines for Seismic Restraints.

Selection of isolator anchors and restraints shall be clearly made known along with the basis for selection so that proposed systems can be reviewed.

Calculations furnished for anchors, anchor bolts, sole plates and other support steel for restraining devices shall be signed and stamped by an engineer licensed in one of the United States.

1.5 REFERENCES:

A. CODES AND STANDARDS:

International Building Code	2003 Edition
NFPA bulletin 90A,	Current Edition
UL Standard 181	
Seismic Restraint Manual Guidelines for Mechanical Systems published by SMACNA	

Guidelines for seismic restraint of Mechanical Systems and Plumbing Piping Systems. Published by the Sheet Metal Industry Fund of Los Angeles, California, and the Plumbing and Piping Industry Council, Inc., Los Angeles, California.

1.6 SEISMIC VENDORS: Mason, Amber Booth, Kinetics.

PART II - PRODUCTS:

2.1 MATERIALS - PRODUCTS: Restraint devices shall be especially designed to resist seismic forces in all directions.

A. SNUBBERS: Restraint surfaces which engage under seismic motion shall be cushioned with a resilient elastomer neoprene (bridge bearing neoprene) to protect equipment. Restraints shall allow a maximum of 1/4" before engaging and shall not interfere in normal starting or stopping operation. Housing shall allow for visual inspection to determine clearances during system operation. Restraints shall be field adjustable and be positioned for up to 1/4" clearance both horizontally and vertically. Mountings and snubbers are to be manufactured under a Quality Assurance (QA) Program.

B. SNUBBERS AND ISOLATOR COMBINATION DEVICES: Combination unitized devices may be used where equipment isolation is required. They shall include the requirements listed for snubbers. Isolation portion shall be stable spring type with combination leveling bolt and equipment fastening device. Base plate shall have adequate means for bolting to structure. The spring assembly shall be removable and shall fit within a welded steel enclosure.

C. PIPING AND CONDUIT RESTRAINTS: Restraint materials for exposed installation shall be standard fabricated flat steel, angle rod and channel members. Restraint members shall be bolt connected. Cabling materials and methods shall be used only in chases or concealed ceiling spaces.

PART III - EXECUTION

3.1 SEISMIC RESTRAINT GUIDELINE:

Guidelines for SMACNA seismic restraints for conduit, piping and ductwork are to serve as the basis for restraint methods.

3.2 SEISMIC RESTRAINT-PIPING AND CONDUIT:

A. General: All piping and conduit shall be protected in all planes by restraints, designed to accommodate thermal movement as well as restrain seismic motion. Tanks and vessels connected to piping shall be restrained in the same manner as the piping.

B. Locations of the restraints shall include, but not be limited to:

1. At all drops or risers to equipment connections.

2. At all changes in direction of piping and conduit.

3. At all horizontal runs of pipe and conduit to keep it in alignment and prevent sagging with restraints not to exceed the following:

Transverse bracing at 40'-0" O.C. maximum.
Longitudinal bracing at 80'-0" O.C. maximum.

4. Provide flexibility in joints where pipes pass through building seismic or expansion joints.

5. On both sides of flexible connectors.

C. Exceptions:

1. Conduit under 2-1/2" size and piping under 1-1/2" size need not be additionally seismically restrained except as follows:

a. Brace all piping and conduit 1-1/4" and larger in boiler rooms, mechanical rooms, electrical equipment rooms and refrigeration machinery rooms.

b. Brace all fuel gas and oil piping, medical gas piping and compressed air piping 1" and larger.

2. Seismic bracing may be omitted:

a. When the top of the pipe is suspended 12" or less from the supporting structure member and the pipe or conduit is suspended by an individual hanger.

b. On all piping 3/4" and smaller.

3.3 SEISMIC RESTRAINT INSULATED PIPING: Where piping is designated to be insulated, the points of support shall be protected by a 360^{o} sheet metal shield. Insert insulation shall be of the same thickness as the adjoining pipe insulation. (Pipe Shields, Inc.)

The sheet metal shield wrapped around the insert shall be of the following lengths and gauge thickness.

PIPE SIZE	SHIELD LENGTH	MINIMUM GAUGE
1/2 - 1-1/2"	4"	20
2 - 6"	6"	20
8 - 10"	9"	16
12 - 18"	12"	16
20 and up	18"	16

3.4 SEISMIC RESTRAINT - PIPING AT FIRE-WALL AND FLOOR PENETRATION WHERE WALL IS USED AS A RESTRAINT:

A. BARE PIPE: Encase pipe in minimum 24 gauge sheet metal can sized for one inch spacing between pipe and outer diameter of can. Spacing shall be packed in accordance with fire resistant/retardant materials in accordance with Section: FIRE PROTECTION, Section 07270.

B. INSULATED PIPE: Encase in adjustable or fixed length cans, minimum 24 gauge, sized for maximum one inch spacing between insulation and outer diameter of can. Insulation shall consist of 360^{o} insert sized to extend a minimum of 1" beyond wall or floor penetration and of the same thickness as the adjoining insulation. Spacing between shield and can shall be packed in accordance with Section: FIRE PROTECTION, Section 07270.

3.5 SEISMIC RESTRAINT GROOVED PIPING: Where grooved piping is selected as the piping system, it must be seismically restrained as well as provide for thermal movement.

Pipes may not be fastened to differently moving structures such as a wall or a ceiling, or a ceiling and a floor. The intent is to have the piping system move with the structure and not separate from it.

In general, grooved piping shall be provided with additional flexible couplings to allow extreme deflections to occur, yet restrained to prevent movement beyond the limits of the flexible connections. Linear movement shall be incorporated as a part of the flexible connections or in a swing joint arrangement.

Groove piping systems shall be separated, analyzed and submitted from threaded or welded piping systems.

3.6 VIBRATION ISOLATION:

A. General: Furnish and install devices to isolate moving equipment from the structure. Review isolation furnished with factory package equipment, require conformance with project criteria.

B. Basic Criteria: Vibration isolation devices which have natural frequencies approximately 1/10 that of the related driving frequency.

C. Field Verify: All required devices and installation.

3.7 VIBRATION ISOLATION - PIPING:

A. Furnish and install devices to isolate all piping from other moving equipment. Provide flex connections, spring hangers, grooved joint couplings for pipe, etc., as required.

3.8 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220548

SECTION 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specifications sections, apply to work of this section.

B. Division-22 Plumbing sections apply to work of this section.

1.2 SCOPE OF WORK:

A. All plumbing piping and equipment (excluding thermostats and relays), and distribution systems shall be labeled. Electrical switches and starters for plumbing equipment shall also be labeled.

PART II - GENERAL PLUMBING MATERIALS AND METHODS

2.1 EQUIPMENT, VALVE PIPE AND DUCT IDENTIFICATION:

A. Items to be labeled shall include all items of plumbing equipment including pumps, and electrical switches and starters for plumbing equipment and gages.

B. Information to be put on label shall include the following:

1. Identification number and name. This number and name shall generally be the same as that shown on the plans or in these specifications.

2. Where the item is a pump, the flow and head shall be indicated and the system served.

3. If part of a unit, it shall have, in addition to its own number, the number of the main item it is serving.

4. Valves shall be tagged as to the area served and have their normal operating position indicated.

5. Where it is apparent which main unit a valve is serving, only the function of the valve need be included on the nameplate.

6. Type of nameplates shall be as follows:

   a. Valve tags shall be aluminum embossed 3/4" tags with identification on one side for valves. Tags for magnetic starters shall be glued to the metal starter cover. Tags shall be as manufactured by Addressograph Company and shall be Addressograph No. B-5300.

   b. Equipment nameplates shall be black face formica with white engraved lettering 3/16" high or larger.

7. Methods of attaching labels shall be as follows:

   a. Valve tags to be connected to valve stem by steel rings or chains.

   b. Screws for equipment labels.

8. Example of typical nameplate series:

   a. Pump nameplate for above unit:

      1) "HW PUMP NO. 2
      2) SERVES FAN A
      3) 700 GPM - 95 FT."

   b. Switch nameplate for above pump:

      1) "MAGNETIC STARTER - PUMP 2"

   c. Sample nameplate for valve where it is apparent what valve is serving:

      1) "DOM. COLD WATER TO ROOMS 380, 381, 382, - N.O."

9. NOTE: Above are samples and do not necessarily apply to actual conditions. Room numbers shall be as assigned by Owner to actual conditions.

C. Identification of Piping:

1. All piping shall bee painted under general painting section of this specification and be identified under this section in accordance with the following:

2. Means of Identification: All campus piping systems shall be identified according to one of the following schemes:

   a. MECHANICAL/FAN ROOM SYSTEMS:

      1) Completely Painted per Coding Scheme
      2) Identifying Legend
      3) Flow Direction Arrow

   b. EXPOSED SYSTEMS:

      1) Completely Painted per Coding Scheme

   c. CONCEALED SYSTEMS:

      1) Identifying Legend
      2) Flow Direction Arrow

3. In concealed space, identify at the following interval:

   a. Every 50 feet interval along continuous runs.

   b. At least once in every room if less than 50 feet

   c. At each riser or junction.

   d. Above or behind ceiling or wall access doors.

4. Colors: The following colors shall be used in accordance with the pipe identification code hereinafter specified.

   a. IMPORTANT! Painting contractor shall not vary from the colors listed below that match campus standard, except ONLY by the written permission from Architect/Engineer or campus Utility Services personnel; to change colors will result in piping being repainted at the sole expense of the contractor.

b. Color Coding as follows:

Material	Background Color	Identifying Legend	Lettering
Air	Blue	Compressed Air	White
Domestic Cold	Yellow	Cold Water	Black
Domestic Hot	Yellow	Hot Water	Black
Domestic Hot Return	Lime	Hot Water Return	Black
Roof Drain	Black	Drain Water	White
Waste	Black	Waste Water	White

5. Identifying Legends: Legends shall be painted or stenciled on pipe over background color in such a location on the pipe as to be readily visible to operating personnel from the floor. Legends must be painted on in black or white as indicated. Self-adhesive or glue-on type labels will not be acceptable.

   a. Letters for identifying legends shall be 2" high for 3" and larger pipe, 1" for 1-1/4" to 2-1/2" pipe and 1/2" for 1" pipe and smaller.

6. 1. Flow Direction Arrows: Arrows to indicate direction of flow inside the pipe shall be painted over the background color in black or white, the same color as the identifying legend and point away from it.

   a. The “shaft” of the arrow shall be 2" long and shall be 1" in width on pipes 3" in diameter or more and 1/2" in width on pipes 2-1/2" in diameter or less. The “head” of the arrow shall be formed by an equilateral triangle having a base equal to twice the width of the “shaft”.

   b. Use double-headed arrow if flow can be in both directions, such as expansion lines.

   c. Identify direction in mechanical rooms not in exposed public ways at walls and every 20 feet.

2.2 PANEL IDENTIFICATION:

A. All panel devices on panel faces shall have engraved plastic labels.

B. All internal panel components shall have engraved plastic labels. Fasten label beneath each device.

C. All panel wiring and tubing shall be numerically or alphabetically coded.

PART 3 – EXECUTION

3.01 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220553

SECTION 22 07 00 - PLUMBING INSULATION

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections apply to work of this section.

B. Division-22 Section 22 00 00 - Plumbing applies to work of this section.

1.2 SUMMARY:

A. Extent of plumbing insulation required by this section is indicated on drawings and schedules as required by the current Model Energy Code, and by requirements of this section. Use no asbestos in this work.

B. Types of plumbing insulation specified in this section include the following:

1. Piping Systems Insulation:

a. Fiberglass.
b. Flexible Unicellular

C. Refer to Division-22 section "Hangers and Supports for Plumbing Piping and Equipment" for protection saddles, protection shields, and thermal hanger shields.

D. Refer to Division-22 section "Identification for Plumbing Piping and Equipment" for installation of identification devices for piping and equipment.

1.3 QUALITY ASSURANCE:

A. MANUFACTURER'S QUALIFICATIONS: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. INSTALLER'S QUALIFICATIONS: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. FLAME/SMOKE RATINGS: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.4 SUBMITTALS:

A. PRODUCT DATA: Submit manufacturer's specifications and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each plumbing system requiring insulation.

B. MAINTENANCE DATA: Submit maintenance data and replacement material lists for each type of plumbing insulation. Include this data and product data in maintenance manual.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Deliver insulation, coverings, cements, adhesives and coatings to site in containers with manufacturer's stamp or label affixed showing fire hazard ratings of products.

B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART II - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. MANUFACTURER: Subject to compliance with requirements, provide plumbing insulation materials of one of the following (except as noted):

1. Armstrong World Industries, Inc.
2. Babcock and Wilcox Co., Insulating Products Div.
3. CertainTeed Corp.
4. Knauf Fiber Glass GmbH.
5. Manville Products Corp.
6. Owens-Corning Fiberglass Corp.
7. Pittsburgh Corning Corp.
8. Rubatex Corp.
9. Thermacell
10. IMOCA

2.2 PIPING INSULATION MATERIALS:

A. PREFORMED FIBERGLASS PIPING INSULATION: ASTM C 547. (Class 1 for use to 450°F (230°C); Class 2 for use to 650°F (345°C); Class 3 for use to 1200°F (650°C).

B. CELLULAR GLASS PIPING INSULATION: ASTM C 552. (Type I - flat block; Type II - pipe and tubing insulation, Class 1 - regular (uncovered), Class 2 - jacketed; Type III - special shapes; Type IV roof board.

C. JACKETS FOR PIPING INSULATION: All purpose (ASJ) fire retardant jacket, ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

D. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.

E. Encase exterior fittings insulation and piping with aluminum jacket with weather-proof construction.

F. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

G. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

2.3 PIPING SEALANT THROUGH WALLS: See also Division X Section.

A. Sealant shall be a two-part foamed silicone elastomer equal to Dow Corning 3-6548 Silicone RTV foam. Sealant shall be applied at any piping or duct penetration through fire or smoke walls to prevent air from passing through the opening.

B. Sealant cell structure, foamed in place, shall be U.L. classified and shall meet the smoke development and fuel contribution ratings specified. Sealant shall be stable at extreme temperatures, and shall effectively confine such hazards as fire, smoke and gases.

C. Sealant required at any fire/smoke wall penetration to be according to approved detail for each specific wall assembly. Contractor shall submit detail for engineer approval.

2.4 FIRE/SMOKE ENCASEMENT:

A. Any and all PVC, PVDF, polypropylene, acid waste and vent and any other plastic piping located in return air plenums shall be encased in rated flame and smoke system. The encasement shall be equal to Firemaster “Plastic Pipe Fire Protection System.” The enclosure shall meet all codes.

PART III - EXECUTION

3.1 GENERAL:

A. Piping insulation shall be fiberglass one-piece performed pipe insulation with all purpose (ASJ) fire retardant jacket.

B. Fittings and valves shall be insulated and covered with Zeston covers.

C. All cold water, roof drains or any other lines upon which condensate moisture could form, shall have a vapor-proof jacket.

D. Fire and smoke hazard for a complete insulation system shall not exceed:

1. Flame spread - 25
2. Fuel contribution - 50
3. Smoke development - 50

E. Insulation protection shields equal to Grinnell Figure 167 shall be installed on all insulated pipe 1" and larger. Hangers shall not contact pipe where pipe is specified to be insulated.

3.2 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.3 PLUMBING PIPING SYSTEM INSULATION:

A. INSULATION OMITTED: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions strainers check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, fire protection piping, and pre-insulated equipment.

B. COLD PIPING:

Application Requirements: Insulate the following cold plumbing piping systems:

1. Potable cold water piping, chilled domestic water supply and return

2. Roof drain bodies

3. Interior above-ground storm water piping, including roof drain, deck drain and landscape drain piping.

4. Plumbing vents within 6 lineal feet of roof or wall outlet.

Insulate each piping system specified above with one of the following types and thicknesses of insulation:

1. Fiberglass with all service jacket, self sealing lap:
1" thickness.

2. Flexible Unicellular: 1/2" thickness.

C. HOT PIPING:

Application Requirements: Insulate the following hot plumbing piping systems:

1. Potable hot water piping.
2. Potable hot water recirculating piping.
3. Hot drain piping (where indicated).

Insulate each piping system specified above with one of the following types and thicknesses of insulation:

1. Fiberglass with all service jacket, self-sealing lap K factor of .24 to .28 at 100^{o} mean rating temperature; 1" thick for pipe sizes up to and including 2"; 1-1/2" thick for pipe sizes over 2".

2. Flexible Unicellular: 1/2" thick for pipe sizes up to and including 2" (largest size permitted) with contact cement or heat fused joints.

3.4 INSTALLATION OF PIPING INSULATION:

A. GENERAL: Install insulation products in accordance with the manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

3.5 PROTECTION AND REPLACEMENT:

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. PROTECTION: Insulation Installer shall advise Contractor of required protection for insulation work during construction period to avoid damage and deterioration.

3.6 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 220700

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

010800 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

220000	General Plumbing requirements
220100	Operation and maintenance of plumbing
220519	Meters and gages for plumbing piping
220523	General Duty valves for plumbing piping
220529	`Hangers and supports for plumbing piping and equipment
220548	Seismic and vibration control
220553	Identification for plumbing piping and equipment
220700	Plumbing insulation
221000	General pipes and fittings
221100	Facility water and distribution
221300	Facility sanitary sewerage
221400	Facility storm drainage
223100	Domestic water softeners
223436	Commercial gas domestic water heaters
224000	`Plumbing fixtures

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner’s operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 01 08 00, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 01 08 00, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Plumbing Systems						
Domestic Pipe Pressure Testing		NA				
Domestic Piping Cleaning/ Disinfection Certificate		NA				
Drain Waist Pressure Testing		NA				
Back Flow Device Certification		NA				
System Readiness Checklist		CA Provided				
Domestic Hot Water Heater						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Domestic Hot Water Pumps						

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A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				

Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.

B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.

C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.

D. Indicates that CA has received and approved proposed installation and start-up documentation.

E. Date the completed documents are received by the CA from the responsible Contractor.

F. Indicates that CA has received and approved completed documentation.

G. Notes on status of forms, irregularities and rework needed.

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Plumbing Systems
System Readiness Checklist (Preliminary Version)

Installation:

- Unions installed on all equipment requiring disconnects for servicing.
- Dielectric unions installed on all dissimilar materials.
- Pressure and temperature gages installed at all specified points, gage range as specified.
- Mechanical supporting devices installed at specified locations and spacing.
- Valves provided and installed per specification in regards to connection style and size.
- Valves installed for area and group isolation, maintenance isolation and service disconnects.
- Piping insulation is complete.
- Piping systems labeled per project documents including direction of flow.
- Access panels installed where applicable for all serviceable components.
- Back flow devices installed per project documents
- Water heaters installed and verified operational.
- All plumbing fixtures installed and verified operational.
- Drain and waste piping complete.
- Equipment and systems are labeled per project documents.

Start-Up:

- Commissioning Authority notified for witness of start-up and testing.
- Domestic water pipe pressure tested, cleaned and disinfected
- Back flow devices tested and certified
- Drain waist and vent system pressure tested

Readiness:

- Manufacturer's installation and start-up procedures were followed. Attach completed checklists.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- Area and equipment have been cleaned, construction debris removed.
- All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Domestic Hot Water Heaters – Gas
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Associated piping, shutoff valves, control valves and insulation are complete.

Expansion tank installed and has been checked for proper charge.

Gas supply complete including shut off valve, flex connection and drip leg.

All gages and thermometers are installed per project documents.

Stacks and breaching complete, make up air provided.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate, disconnect labeled.

External controls installed.

Start-Up:

Commissioning Authority notified for witness of start-up.

Internal controls and safeties verified operational.

External controls verified operational.

Operating parameters measured and recorded.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Domestic Hot Water Pumps
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided.
- Equipment and systems are labeled per project documents.
- Pumps mounted per project documents.
- Associated piping, shutoff valves, control valves and insulation are complete.
- All balancing and check valves, gages and thermometers are installed per project documents.
- Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- External controls installed.
- All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

- Commissioning Authority has been notified for witness of start-up.
- Voltage and phase has been verified.
- Pumps have been properly adjusted and aligned.
- Motor operation and rotation verified.
- Pumps have been lubricated.
- Pumps have been aligned.
- Internal controls and safeties verified operational.
- External controls verified operational.
- Operating parameters measured and recorded.

Readiness:

- Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturer’s checklists.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- Area and equipment have been cleaned, construction debris removed.
- All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
	Responsible Contractor	Proposed Test Forms Received	OK	Testing Complete	OK	Notes
Piping Systems						
Plumbing Fixtures						
Hot Water Heaters/Pumps						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Domestic Water Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	25%

Functional Tests:

1) Distribution
   a) Pump Operation

2) Fixture Operation
   a) Faucets
   b) Showers
   c) Toilets
   d) Drinking Fountains
   e) Automatic fixtures

3) Water Heater
   a) Temperature control
   b) Relief

4) Mixing Valves
   a) Temperature control

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A System Description	B Responsible Contractor	C Proposed Agenda Received	D OK	E Training Performed	F OK	G Closeout Form Received	H OK	I Notes
Piping Systems								
Plumbing Fixtures								
Hot Water Heaters/Pumps								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

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Welsh Commissioning Group, Inc
4508 Auburn Way N., Suite E
Auburn, WA 98002

Plumbing Fixture-Water Closet Installation Verification and Test

Key:
D = Fixture installed correctly & operational.
C= Caulked to mounting surface.
I = Fixture and valve Installed with per detail
F= Flush cycle correct.
FF=Flush flow correct (does not splash out of bowl).
S = Flush valve shuts off after cycle completed.
DL=No leaks between fixture and mounting surface.
.

Project: _____

Unit No.	Drwg No.	Grid Location	Description/Location	Observation							Note
				D	C	I	F	FF	S	DL	

Commissioning Authority: Date:

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Welsh Commissioning Group, Inc.
4508 Auburn Way N., Suite E
Auburn, WA 98002

Plumbing Equipment
Installation Verification and Test
Mixing Valves

Key:
I = Installed per Detail
A = Accessible
L = Labeled per project documents
S = Setting of dial or handwheel
T = Mixed water temperature

Project: _____

Unit No.	Drwg No.	Grid Location	Description/Location	Observation			Start-Up		Note
				I	A	L	S	T	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

Commissioning Authority: Date:

END OF SECTION 220800

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SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

010800 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

220000	General Plumbing requirements
220100	Operation and maintenance of plumbing
220519	Meters and gages for plumbing piping
220523	General Duty valves for plumbing piping
220529	`Hangers and supports for plumbing piping and equipment
220548	Seismic and vibration control
220553	Identification for plumbing piping and equipment
220700	Plumbing insulation
221000	General pipes and fittings
221100	Facility water and distribution
221300	Facility sanitary sewerage
221400	Facility storm drainage
223100	Domestic water softeners
223436	Commercial gas domestic water heaters
224000	`Plumbing fixtures

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner’s operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 01 08 00, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 01 08 00, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Plumbing Systems						
Domestic Pipe Pressure Testing		NA				
Domestic Piping Cleaning/ Disinfection Certificate		NA				
Drain Waist Pressure Testing		NA				
Back Flow Device Certification		NA				
System Readiness Checklist		CA Provided				
Domestic Hot Water Heater						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Domestic Hot Water Pumps						

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A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				

Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.

B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.

C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.

D. Indicates that CA has received and approved proposed installation and start-up documentation.

E. Date the completed documents are received by the CA from the responsible Contractor.

F. Indicates that CA has received and approved completed documentation.

G. Notes on status of forms, irregularities and rework needed.

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Plumbing Systems
System Readiness Checklist (Preliminary Version)

Installation:

- Unions installed on all equipment requiring disconnects for servicing.
- Dielectric unions installed on all dissimilar materials.
- Pressure and temperature gages installed at all specified points, gage range as specified.
- Mechanical supporting devices installed at specified locations and spacing.
- Valves provided and installed per specification in regards to connection style and size.
- Valves installed for area and group isolation, maintenance isolation and service disconnects.
- Piping insulation is complete.
- Piping systems labeled per project documents including direction of flow.
- Access panels installed where applicable for all serviceable components.
- Back flow devices installed per project documents
- Water heaters installed and verified operational.
- All plumbing fixtures installed and verified operational.
- Drain and waste piping complete.
- Equipment and systems are labeled per project documents.

Start-Up:

- Commissioning Authority notified for witness of start-up and testing.
- Domestic water pipe pressure tested, cleaned and disinfected
- Back flow devices tested and certified
- Drain waist and vent system pressure tested

Readiness:

- Manufacturer's installation and start-up procedures were followed. Attach completed checklists.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- Area and equipment have been cleaned, construction debris removed.
- All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Domestic Hot Water Heaters – Gas
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Associated piping, shutoff valves, control valves and insulation are complete.

Expansion tank installed and has been checked for proper charge.

Gas supply complete including shut off valve, flex connection and drip leg.

All gages and thermometers are installed per project documents.

Stacks and breaching complete, make up air provided.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate, disconnect labeled.

External controls installed.

Start-Up:

Commissioning Authority notified for witness of start-up.

Internal controls and safeties verified operational.

External controls verified operational.

Operating parameters measured and recorded.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Domestic Hot Water Pumps
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided.
- Equipment and systems are labeled per project documents.
- Pumps mounted per project documents.
- Associated piping, shutoff valves, control valves and insulation are complete.
- All balancing and check valves, gages and thermometers are installed per project documents.
- Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- External controls installed.
- All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

- Commissioning Authority has been notified for witness of start-up.
- Voltage and phase has been verified.
- Pumps have been properly adjusted and aligned.
- Motor operation and rotation verified.
- Pumps have been lubricated.
- Pumps have been aligned.
- Internal controls and safeties verified operational.
- External controls verified operational.
- Operating parameters measured and recorded.

Readiness:

- Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturer’s checklists.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- Area and equipment have been cleaned, construction debris removed.
- All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

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3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

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6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

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	Responsible Contractor	Proposed Test Forms Received	OK	Testing Complete	OK	Notes
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Plumbing Fixtures						
Hot Water Heaters/Pumps						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Domestic Water Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	25%

Functional Tests:

1) Distribution
   a) Pump Operation

2) Fixture Operation
   a) Faucets
   b) Showers
   c) Toilets
   d) Drinking Fountains
   e) Automatic fixtures

3) Water Heater
   a) Temperature control
   b) Relief

4) Mixing Valves
   a) Temperature control

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A System Description	B Responsible Contractor	C Proposed Agenda Received	D OK	E Training Performed	F OK	G Closeout Form Received	H OK	I Notes
Piping Systems								
Plumbing Fixtures								
Hot Water Heaters/Pumps								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

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Welsh Commissioning Group, Inc
4508 Auburn Way N., Suite E
Auburn, WA 98002

Plumbing Fixture-Water Closet Installation Verification and Test

Key:
D = Fixture installed correctly & operational.
C= Caulked to mounting surface.
I = Fixture and valve Installed with per detail
F= Flush cycle correct.
FF=Flush flow correct (does not splash out of bowl).
S = Flush valve shuts off after cycle completed.
DL=No leaks between fixture and mounting surface.
.

Project: _____

Unit No.	Drwg No.	Grid Location	Description/Location	Observation							Note
				D	C	I	F	FF	S	DL	

Commissioning Authority: Date:

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Welsh Commissioning Group, Inc.
4508 Auburn Way N., Suite E
Auburn, WA 98002

Plumbing Equipment
Installation Verification and Test
Mixing Valves

Key:
I = Installed per Detail
A = Accessible
L = Labeled per project documents
S = Setting of dial or handwheel
T = Mixed water temperature

Project: _____

Unit No.	Drwg No.	Grid Location	Description/Location	Observation			Start-Up		Note
				I	A	L	S	T	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

Commissioning Authority: Date:

END OF SECTION 220800

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SECTION 221000 – PLUMBING PIPING AND PUMPS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. This section is Division-15 Basic Mechanical Materials and Methods section, and is part of each Division-15 section making reference to pipes and pipe fittings specified herein.

1.2 SUMMARY:

A. This section is generic in that it describes material and installation required by several other sections of this specification.

B. Types of pipes and pipe fittings specified in this section include the following:

1. Steel Piping
2. Copper Piping
3. Cast-Iron Pressure Piping
4. Cast-Iron Soil Piping
5. Grooved Joint Piping
6. Miscellaneous Piping Materials/Products.

C. Pipes and pipe fittings furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-15 sections.

1.3 QUALITY ASSURANCE:

A. MANUFACTURER'S QUALIFICATIONS: Firms regularly engaged in manufacture of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. INSTALLER'S QUALIFICATIONS:

1. Firm with at least three years history of successful experience on projects of similar nature.

2. Licensed as a firm in the contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the contractor.

4. All workmen employed on the project shall carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

C. WELDING CERTIFICATION:

1. Each welder shall have passed a qualification test within the past six months of starting work on the project.

2. The test shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, "Welding Qualifications", ASME Section VIII, and ANSI 313.

3. The test report shall certify that the welder is qualified to weld the material to be used at the job site.

4. Submit three copies of each welder's qualification test report to the Project Manager for approval prior to commencing the work. No welder shall be used on the project until so certified.

1.4 SUBMITTALS:

A. PRODUCT DATA: Submit manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing manufacturer, pipe or tube weight, fitting type, and joint type for each piping system.

B. WELDING CERTIFICATIONS: Submit reports as required for piping work.

C. BRAZING CERTIFICATIONS: Submit reports as required for piping work.

D. MAINTENANCE DATA: Submit maintenance data and parts lists for each type of mechanical fitting. Include this data, product data, and certifications in maintenance manual; in accordance with requirements of Division 1.

1.5 REFERENCES:

A. CODES AND STANDARDS:

1. Welding: Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9, as applicable, for shop and project site welding of piping work.

2. Brazing: Certify brazing procedures, brazers, and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

3. NSF Labels: Where plastic piping is indicated to transport potable water, provide pipes and pipe fittings bearing approval label by National Sanitation Foundation (NSF).

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Except for concrete, corrugated metal, hub-and-spigot, clay, and similar units of pipe, provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps through shipping, storage and handling as required to prevent pipe-end damage and eliminate dirt and moisture from inside of pipe and tube.

B. Where possible, store pipe and tube inside and protected from weather. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.

C. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART II - PRODUCTS

2.1 GENERAL:

A. PIPING MATERIALS: Provide pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards. Use United States (domestic) manufactured pipe only. Do not use foreign made pipe.

B. PIPE/TUBE FITTINGS: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable. Use domestic manufactured fittings only. Do not use foreign manufactured fittings.

2.2 COPPER TUBE AND FITTINGS:

A. COPPER TUBE: ASTM B 88; Type K, L (wall thickness) as indicated for each service; hard-drawn temper, except as otherwise indicated.

B. DWV COPPER TUBE: ASTM B 306.

C. ACR COPPER TUBE: ASTM B 280.

D. CAST-COPPER SOLDER-JOINT FITTINGS: ANSI B16.18.

E. WROUGHT-COPPER SOLDER-JOINT FITTINGS: ANSI B16.22.

F. CAST-COPPER SOLDER-JOINT DRAINAGE FITTINGS: ANSI B16.23.

G. WROUGHT-COPPER SOLDER-JOINT DRAINAGE FITTINGS: ANSI B16.29.

H. CAST-COPPER FLARED TUBE FITTINGS: ANSI B16.26.

I. BRONZE PIPE FLANGES/FITTINGS: ANSI B16.24.

J. COPPER-TUBE UNIONS: Provide standard products recommended by manufacturer for use in service indicated.

2.3 CAST-IRON SOIL PIPES AND PIPE FITTINGS:

A. HUBLESS CAST-IRON SOIL PIPE: FS WW-P-401.

B. CAST-IRON HUB-AND-SPIGOT SOIL PIPE: ASTM A 74.

C. HUBLESS CAST-IRON SOIL PIPE FITTINGS: Neoprene gasket complying with ASTM C 564 and stainless steel clamp holding band.

D. CAST-IRON HUB-AND-SPIGOT SOIL PIPE FITTINGS: Match soil pipe units; complying with same standards (ASTM A 74).

E. COMPRESSION GASKETS: ASTM C 564.

F. LEAD/OAKUM JOINT MATERIALS: Provide products complying with governing regulations for use in service indicated.

2.4 GROOVED PIPING PRODUCTS: (Only where acceptable.)

A. GENERAL: As Installer's option, mechanical grooved pipe couplings and fittings may be used for piping systems having operating conditions not exceeding 230^{o}F (110^{o}C), excluding steam piping and any other service not recommended by manufacturer, in lieu of welded, flanged, or threaded methods, and may also be used as unions, seismic joints, flexible connections, expansion joints, expansion compensators, or vibration reducers.

B. COUPLING HOUSINGS DESCRIPTION: Grooved mechanical type, which engages grooved or shouldered pipe ends, encasing an elastomeric gasket which bridges pipe ends to create seal. Cast in two or more parts, secure together during assembly with nuts and bolts. Permit degree of contraction and expansion as specified in manufacturer's latest published literature. (Victaulic style 77) For rigid joints (Victaulic "Zero Flex" style 07).

1. Coupling Housings: Malleable iron conforming to ASTM A 47.

2. Coupling Housings: Ductile iron conforming to ASTM A 536.

3. Standard: Enamel coated, options hot dip galvanized.

C. GASKETS: Mechanical grooved coupling design, pressure responsive so that internal pressure serves to increase seal's tightness, constructed of elastomers having properties as designated by ASTM D 2000.

1. Water Services: EDPM Grade E, with green color code identification.

2. Other Services: As recommended by Manufacturer.

D. BOLTS AND NUTS: Heat-treated carbon steel, ASTM A 183, minimum tensile 110,000 psi.

1. Exposed Locations: Tamper resistant nuts.

E. BRANCH STUB-INS: Upper housing with full locating collar for rigid positioning engaging machine-cut hole in pipe, encasing elastomeric gasket conforming to pipe outside diameter around hole, and lower housing with positioning lugs, secured together during assembly with nuts and bolts.

F. FITTINGS: Grooved or shouldered end design to accept grooved mechanical couplings.

1. Malleable Iron: ASTM A 47.

2. Ductile Iron: ASTM A 536.

3. Fabricated Steel: ASTM A 53, Type F for 3/4" to 1-1/2"; Type E or S, Grade B for 2" to 20".

4. Steel: ASTM A 234.

G. FLANGES: Conform to Class 125 cast iron and Class 150 steel bolt hole alignment.

1. Malleable Iron: ASTM A 47.

2. Ductile Iron: ASTM A 536.

H. SPECIALTIES:

1. Inline strainers. Victaulic Style 730.

2. Suction diffusers. Victaulic Style 731.

3. Dielectric couplings. Victaulic Style 47.

I. GROOVES: Conform to the following:

1. Standard Steel: Square cut or roll grooved.

2. Lightweight Steel: Roll grooved.

3. Ductile Iron: Radius cut grooved, AWWA C606.

J. MANUFACTURER: Subject to compliance with requirements, provide grooved piping products of one of the following:

1. ITT Grinnell Corp.
2. Stockham Valves & Fittings, Inc.
3. Victaulic Co. of America.
4. Gustin-Bacon.

2.5 ACID RESISTANT PIPING:

A. ACID RESISTANT CAST IRON PIPE AND FITTINGS: Bell and spigot type, high silicon iron alloy “Duriron”, with chemical resistant packing and caulked lead joints.

B. POLYPROPYLENE PIPE: Use for exposed drainage piping above grade. Orion Blueline, flame retardant, Schedule 40, with Schedule 40 fittings, heat fusion welded joints. Alternate manufacturers, GSR, Enfield. Meet material standards of ASTM-D4101, joint standards of ASTM-D2657. Provide UL listed sleeve assembly at penetration of fire rated walls, or use Duriron section.

2.6 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

A. WELDING MATERIALS: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.

Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.

B. SOLDERING MATERIALS: Except as otherwise indicated, provide soldering materials as determined by Installer to comply with installation requirements. Use no lead bearing solders in domestic water applications.
Tin-Antimony Solder: ASTM B 32, Grade 95TA.

Silver-Lead Solder: ASTM B 32, Grade 96TS.

C. BRAZING MATERIALS: Except as otherwise indicated, provide brazing materials as determined by Installer to comply with installation requirements.

Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.

D. GASKETS FOR FLANGED JOINTS: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.

E. PIPING CONNECTORS FOR DISSIMILAR NON-PRESSURE PIPE: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.

MANUFACTURER: Subject to compliance with requirements, provide piping connectors of the following:

1. Fernco, Inc.

2.7 STRAINERS:

A. Y pattern, self cleaning, line size. Armstrong, Bailey, Crane, Fisher, Mueller, Sarco, Strong, or Yarway.

Iron Body, Screwed Ends 2" and Smaller: 250 psig at 425^{o}F, screen mesh to suit service.

Flanged Iron Body 2-1/2" and Larger: 125 psig steam pressure rating, screen mesh to suit service.

B. Basket pattern, quick release lid. Mueller #155 to 30 psi, Mueller #165 to 125 psi.

2.8 FLOOR, WALL AND CEILING PLATES (ESCUTCHEONS): Where exposed pipes pass through floors, finished walls or finished ceilings, they shall be fitted with chromium plated cast brass flanges with set screws. Plates shall be large enough to completely close the hole around the pipe, and shall be not less than 1-1/2" nor more than 2-1/2" larger than the diameter of the pipes or insulation. All plates shall be securely held in place.

2.9 PROTECTIVE COATINGS: All underground steel pipes shall be wrapped with Scotchwrap No. 50 tape to give not less than two complete layers on the underground piping system, or piping shall have "X-tru Coat", factory applied plastic protective covering, or pipe shall be coated and wrapped with coal tar enamel and Kraft paper, all with coated and taped joints.

2.10 DIELECTRIC/INSULATING FITTINGS: Insulating fittings shall be used to connect dissimilar metals (such as steel and copper) to prevent electrolytic action. Insulating fittings are not required between bronze valves and steel pipe or between copper coil headers and steel pipe.

2.11 FLEXIBLE CONNECTIONS: At pumps, chillers, compressors and at all rotating or vibrating pieces of equipment, provide flexible connectors to accommodate alignment and vibration. A general appropriate connector is Hyspan Series 4500 flexible metal with corrugated stainless steel inner core and braided wrap. Units to be full line size. A series of three Victaulic couplings may be used for water service.

PART III - EXECUTION

3.1 INSTALLATION:

A. GENERAL: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently- leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible union, flanges, etc., for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" misalignment tolerance. Do not cold spring. Store filler weld materials in accordance with codes.

Comply with ANSI B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, columns and other clearance to 1/2" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation. Wherever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated. Provide high point vents, low point drains with valves and extension to drain for all piping.

C. All piping in mechanical rooms, fan rooms, etc., shall be exposed. Do not conceal or imbed piping in walls, floors or other structures.

D. Make changes in direction or size with manufactured fittings. Anchor and support piping for free expansion and movement without damage to piping, equipment or to building.

E. Piping shall be arranged to maintain head room and keep passageways clear.

F. Provide unions at connections to equipment and elsewhere as required to facilitate maintenance.

G. Run full pipe size through shutoff valves, gas cocks, balancing valves, etc. Change pipe size within three pipe size diameters of final connection to equipment, coils, etc.

H. All piping shall be erected to insure proper draining. Air piping shall pitch down in the direction of flow a minimum of 1" per 40 feet. Domestic water, chilled water, heating water, and condenser water shall slope down a minimum of 1" per 40 feet towards the drains. Wet standpipes shall pitch down to fire department connections a minimum of 1" per 40 feet. Refrigerant suction line shall slope a minimum of 1" per 10 feet towards compressor. Soil, waste, vent, and roof drain lines shall slope in accordance with requirements of Uniform Plumbing Code.

I. On horizontal straight runs of pipe, use eccentric reducers with straight side on top for water piping.

J. ELECTRICAL EQUIPMENT SPACES: Do not run piping in or through transformer vaults and other electrical or electronic equipment spaces and enclosures or above electrical gear unless authorized and directed. Install drip pan under piping that must be run through electrical spaces.

3.2 PIPING SYSTEM JOINTS:

A. GENERAL: Provide joints of type indicated in each piping system.

B. THREADED: Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. BRAZED: Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.

D. SOLDERED: Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. WELDED:

1. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31.

2. Weld pipe joints in accordance with recognized industry practice and as follows:

Weld pipe joints only when ambient temperature is above 0^{o}F (-18^{o}C) where possible, with minimum pipe preheat to 50^{o}F.

Bevel pipe ends at a 37.5^{o} angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.

Use pipe clamps or tack-weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".

Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

At Installer's option, install forged branch-connection fittings wherever branch pipe of size smaller than main pipe is indicated; or install regular "T" fitting.

F. FLANGED JOINTS: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

G. HUBLESS CAST-IRON JOINTS: Comply with coupling manufacturer's installation instructions.

H. GROOVED PIPE JOINTS: Comply with fitting manufacturer's instructions for making grooves in pipe ends. Remove burrs and ream pipe ends. Assemble joints in accordance with manufacturer's instructions.

3.3 CLEANING, FLUSHING, INSPECTING:

A. GENERAL: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Disinfect water mains and water service piping in accordance with AWWA C601.
C. Flush, clean and treat heating and cooling systems in accordance with Sections chemical treatment. Certify by signature of Contractor and Owner's Representative.

3.4 PIPING TESTS:

A. GENERAL: Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

1. Required test period is 2 hours.

2. Test long runs of Schedule 40 pipe at 150 psi, except where fittings are lower Class or pressure rating.

3. Test each piping system at 150% of operating pressure indicated, but not less than 25 psi test pressure.

4. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds 5% of test pressure.

B. NOTIFICATIONS: At least 10 working days prior to commencement of required testing, notice shall be submitted for review. Tests shall be made prior to painting insulating or covering of any joints and shall be in accordance with ANSI Code for Pressure Piping.

C. INSPECTIONS: Services of an authorized ASME inspector shall be furnished, not an employee of Contractor, to visually inspect piping while under hydrostatic pressure. Copies of inspection shall be submitted for review. At option of contract, welds not hydrostatically tested may be x-ray tested.

D. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

E. Drain test water from piping systems after testing and repair work has been completed.

F. Test pressure piping in accordance with ANSI B31.

G. Test waste, drain and vent systems in accordance with local plumbing code and these specifications. Repair failed sections by disassembly and reinstallation.

H. If test procedures in other sections differ from the above, comply with more stringent requirements.

3.5 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 221000

SECTION 221000 – FACILITY WATER DISTRIBUTION

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 SUMMARY:

A. This Section specifies the water distribution piping system, including potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building connecting to existing water piping in existing building and connecting to new equipment.

B. Water Supply Systems:

1. Domestic Water
2. Rough-in and Connect

C. Domestic Water Equipment:

1. Domestic Water Circ. Pumps
2. Domestic Water Expansion Tank
3. Water Meter

D. Related Sections:

1. Separate sections in Division 22 specify Basic Piping Materials and Methods, Hangers and Supports, Expansion Compensation, piping system identification materials and requirements, general duty valves, pipe insulation, water conditioning equipment, domestic hot water heaters and plumbing fixtures and equipment.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications:

1. Firms regularly engaged in the manufacture of plumbing piping products and equipment of types, materials and sizes required, whose products have been in service for not less than five years.

B. Installer's Qualifications:

1. Firm with at least three years history of successful experience on projects of similar nature.

2. Licensed as a firm in the Contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

4. All workmen employed on the project shall carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical literature indicating source, brand, type, model, performance characteristics, installation instructions, etc. Color chart for finished surfaces and fixtures.

B. Record Drawings: See Section 15000.

C. Operation And Maintenance Information: Provide information for all equipment including a comprehensive system operating description. See Section 15995.

1.5 REFERENCES:

A. Codes and Standards: Comply with applicable sections, follow recommended practices.

1. State Boiler and Pressure Vessel Regulations
2. ASME Codes for Boilers and Pressure Vessels
3. International Plumbing Code
4. International Building Code
5. International Mechanical Code
6. Americans with Disabilities Act.
7. HI Compliance: Design, manufacture, and install plumbing pumps in accordance with HI "Hydraulic Institute Standards".
8. UL Compliance: Design, manufacture, and install plumbing pumps in accordance with UL 778 "Motor Operated Water Pumps".
9. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Store pipe in a manner to prevent sagging and bending.

1.7 SEQUENCING AND SCHEDULING:

A. Coordinate the installation of pipe sleeves for foundation wall penetrations.

PART II - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer Uniformity: Conform with the requirements specified in Basic Mechanical Requirements, under "Product Options."

2.2 PIPE AND FITTINGS:

A. Domestic Water Pipe Within Building (except below slab):

1. Pipe Sizes 4" and Smaller: Copper tubing. Conform to ASTM B88, Type K or L, hard temper, copper tube; ANSI B16.22 streamlined pattern wrought-copper fittings, with soldered joints using 95-5 tin-antimony solder or non-lead bearing solders such as "Silvabrite".

2.3 VALVES:

A. Ball, butterfly, check, and drain valves are specified in Section 22 05 23 – General-Duty Valves for Plumbing Piping.

2.4 PIPING SPECIALTIES:

A. Water Hammer Arresters: Bellows type, with stainless steel casing and bellows, pressure rated for 250 psi, tested and certified in accordance with PDI Standard WH-201. Zurn, Smith, Wade.

B. Backflow Preventers: Reduced pressure principle assembly consisting of shutoff valves on inlet and outlet, and strainer on inlet. Assemblies shall include test cocks, and pressure-differential relief valve located between two positive seating check valves, and comply with requirements of ASSE Standard 1013. FEBCO 825Y, Watts 909. Install line size. Provide and install at all locations required by Code.

C. Strainers: 3" and smaller shall be Watts No. 777, WWP 250 psi at 210^{o}F, cast bronze body, threaded, solid retainer cap, 20 mesh stainless steel screen (except 3" to have 3/64" perforated screen). 4" and larger shall be cast iron body with electrostatically applied heat, fused epoxy coating on interior and exterior. For use with potable water 1/16 mesh stainless steel screen, flanged end connection, iron retainer cap thread tap for blow off, Class 250, Watts 77F-FDA-250.

D. Pressure Reducing Valves 1-1/2" and Smaller: Bronze body construction integral stainless steel strainer renewable stainless steel seat. High temperature resistant diaphragm. Select proper size for maximum flow rate and inlet and outlet pressures indicated. Comply with ASSE Standard 1003.

1. Approved Manufacturer: Watts U5B.

E. Pressure Reducing Valves Larger than 1-1/2": 250 Class hydraulically operated, single seated, diaphragm actuated, globe pattern, with all internal and external ferrous metal surfaces of main valve body coated with fused epoxy. Diaphragm assembly stem shall be 316 stainless seat shall be easily removed and replaced with out special tools. The diaphragm shall be nylon fabric bonded with Buna N rubber. Pilot valve shall be adjustable direct acting spring located, diaphragm type valve with bronze body stainless steel trim. Select proper size for maximum flow rate and inlet and outlet pressures indicated.

1. Approved Manufacturer: Watts/Muller (Muesco) PV-10.

2.5 RECIRCULATING PUMPS: (RCP)

A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.

B. Product:

1. Type: Horizontal, oil-lubricated, designed for 125 psi working pressure, 225^{o}F (107^{o}C) continuous water temperature, and specifically designed for quiet operation.

2. Body: Bronze or stainless steel construction.

3. Impeller: Bronze

4. Shaft: Steel, ground and polished, integral thrust collar.

5. Bearings: Two horizontal sleeve bearings designed to circulate oil.

6. Seal: Mechanical, with carbon seal face rotating against ceramic seat.

7. Motor: Non-overloading at any point on pump curve, open, drip-proof, sleeve bearings, quiet operating, rubber mounted construction, built-in thermal overload protection.

8. Coupling: Self-aligning, flexible coupling.

9. Manufacturer: Subject to compliance with requirements, provide in-line recirculation pumps of one of the following:

   a. Bell and Gossett
   b. Armstrong
   c. Grundfoss

2.6 DOMESTIC WATER EXPANSION TANKS:

A. Extent of Work: Furnish and install captive air type shock absorbing expansion tanks as indicated on drawings.

B. Delivery Storage and Handling: Handle carefully. Verify integrity of bladder before activating system.

C. Submittals: Submit shop drawings for review.

D. Materials and Installation:

1. NSF approved.

2. ASME stamped for 125 psi working pressure.

3. Butyl rubber diaphragm, propylene lined reservoir. Welded steel tank.

4. Air charging valve, threaded water side connection.

5. Selections based on Amtrol.

6. Install complete with system isolation and water side drain valves, seismic restraint. Charge air side of tank to system water pressure before connection.

2.7 WATER METER:

A. Extent of Work: Provide turbine type water meter for required service on this project. Include all related installation with support, union, isolation valves, bypass, etc.

B. Equipment: Provide turbine type meter constructed to comply with all performance and material standards of AWWA C701, 175 psi working pressure. Bronze housing with flanged connections with sealed register reading gallons sized for 200 gpm flow rate at maximum of 5 psi pressure drop with accuracy of 100% + 1% of flow.

C. Manufacturer: Sensus, DRS or Precision.

PART III - EXECUTION

3.1 EXAMINATION

A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

C. Do not proceed until the unsatisfactory conditions have been corrected.

3.2 JOINING PIPES AND FITTINGS:

A. Copper Tubing: Solder joints in accordance with the procedures specified in ANSI B9.1.

3.3 PIPING INSTALLATION:

A. Refer to the separate Division 15 section: Basic Piping Materials and Methods, for general piping installation instructions.

B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

C. Install piping level with no pitch.

3.4 INSTALLATION OF VALVES:

A. Installation requirements for general duty valves are specified in a separate section of Division 22.

B. Valves: Install in locations shown on drawings. Provide isolation valves for brand lines and service to all equipment, shown or not.

C. Check Valves: Install swing check valves on discharge side of each pump, and elsewhere as indicated.

D. Hose Bibbs and Wall Hydrants: Install where indicated on drawings with vacuum breaker. Each and every hose bibb or wall hydrant shall have a ball valve located upstream of its individual hose bibb or wall hydrant. Locate ball valve in accessible work space.

3.5 INSTALLATION OF PIPING SPECIALTIES:

A. Install backflow preventers at each connection to mechanical equipment and systems, and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Pipe relief outlet without valves, to nearest floor drain. Install each backflow preventer no more than 5'-0" above floor.

B. Install pressure regulating valves with inlet and outlet shutoff valves, and balance cock bypass. Install pressure gage on valve outlet.

3.6 EQUIPMENT CONNECTIONS:

A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts to fixtures of sizes indicated, but in no case smaller than required by Plumbing Code.

B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection, provide drain valve on drain connection. For connections 2-1/2" and larger, use flanges instead of unions.

3.7 WATER SYSTEM SHOCK ABSORBERS:

A. Equip each hot and cold water connection to a fixture or faucet with a full size vertical air cushion not less than 12" long. In addition to the air cushions, provide stainless steel bellows type shock absorbers for hot and cold water at each fixture group. Zurn "Schocktrol" or Smith, Josam, Wade, size to number of fixtures.

3.8 INSTALLATION OF PUMPS:

A. General: Install plumbing pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that plumbing pumps comply with requirements and serve intended purposes.

B. Access: Provide access space around plumbing pumps for service as indicated, but in no case less than that recommended by manufacturer.

C. Support: Install base-mounted pumps on minimum of 4" high concrete base equal or greater than 3 times total weight of pump and motor, with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

D. Install in-line pumps, supported from piping system.

E. Support: Refer to Division-22 section "Vibration Control" for support and mounting requirements of plumbing pumps.

F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

G. Piping Connections: Refer to Division-15 plumbing piping sections. Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated.

3.9 PUMP ADJUSTING AND CLEANING:

A. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, in presence of manufacturer's service representative.

B. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacture's

instructions.

C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.10 FIELD QUALITY CONTROL:

A. Inspections:

B. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.

C. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

D. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.

E. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.

F. Reinspections: Whenever the plumbing official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the plumbing official.

G. Reports: Prepare inspection reports, signed by the plumbing official.

H. Piping System Test:

I. Test for leaks and defects all new water distribution piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.

J. Leave uncovered and unconcealed all new, altered, extended, or replaced water distribution piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.

K. Cap and subject the piping system to a static water pressure of 50 psig above the operating pressure without exceeding the pressure rating of the piping system materials. Isolate the test source and allow to stand for a period of 4 hours. Leaks and loss in test pressure constitute defects which must be repaired.

L. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.

M. Prepare reports for all tests and required corrective action.

3.11 ADJUSTING AND CLEANING:

A. Cleaning and Disinfecting:

1. Purge all new water distribution piping systems prior to use.

2. Follow AWWA guidelines. Thoroughly sterilize the entire domestic water system with a solution containing not more than 50 parts per million of available chlorine. Introduce the chlorinating materials into the system in a manner approved by the Owner's representative. Allow the sterilization solution to remain in the system for a period of 24 hours, during which time, open and close all valves and faucets several times. After sterilization, flush the solution from the system with clean water until the residual chlorine content is not greater than 0.2 parts per million. Water system will not be accepted until a negative bacteriological test is made on water taken from the system. Repeat dosing as necessary until such negative test is accomplished.

B. Reports:

1. Prepare reports for all purging and disinfecting activities.

3.12 INSTRUCTION OF OWNER'S PERSONNEL: Participate in specified instruction. See Section 15000.

3.13 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 221100

SECTION 22 13 00 – FACILITY SANITARY SEWERAGE

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 SUMMARY:

A. This Section specifies building sanitary, storm drainage and vent, acid waste and vent and equipment, vent and drain piping systems, including drains and drainage specialties.

B. Related Sections:

1. Separate sections in Division 2 specify sanitary sewage systems and trenching and backfilling. Provide a complete transition between work components.

2. Separate sections in Division 7 specify flashing and sheet metal and joint sealers.

3. Division 22 Plumbing section applies to the work of this section.

4. Separate sections of Division 22 specify Basic Piping Materials and Methods, Hangers and Supports, Expansion Compensation, piping system identification materials and requirements, pipe insulation, and plumbing equipment.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications:

1. Firms regularly engaged in the manufacture of plumbing piping products and equipment of types, materials and sizes required, whose products have been in service for not less than five years.

B. Installer's Qualifications:

1. Firm with at least three years history of successful experience on projects of similar nature.

2. Licensed as a firm in the Contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

4. All workmen employed on the project shall carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer’s technical literature indicating source, brand, type, model, performance characteristics, installation instructions, etc. Color chart for finished surfaces and fixtures.

B. Record Drawings: See Section 15000.

C. Operation And Maintenance Information: Provide information for all equipment including a comprehensive system operating description. See Section 22 01 00.

1.5 REFERENCES:

A. Codes and Standards: Comply with applicable sections, follow recommended practices.

1. State Boiler and Pressure Vessel Regulations
2. ASME Codes for Boilers and Pressure Vessels
3. State and Local Plumbing and Mechanical Codes
4. International Building Code
5. International Mechanical Code
6. Americans with Disabilities Act.

1.6 SEQUENCING AND SCHEDULING:

A. Coordinate the installation of floor drains, floor sinks and floor/roof penetrations.

B. Coordinate flashing materials installation of roofing, waterproofing, and adjoining substrate work.

C. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.

D. Coordinate with installation of sanitary sewer systems as necessary to interface building drains with drainage piping systems.

PART II - PRODUCTS

2.1 WASTE, DRAIN AND VENT SYSTEMS:

A. Sanitary Soil Drain, Waste and Vent Piping:

1. Service weight hub and spigot cast iron pipe and fittings with lead caulked or Ty-Seal joints.

2. Service weight "No-Hub" cast iron pipe and fittings with neoprene gaskets and stainless steel screw bands (above ground only).

3. Schedule 40 galvanized steel pipe with drainage pattern cast iron screwed fittings (above ground only).

4. Cleanout Plugs and Ferrules: Cleanouts shall be of the same size as pipe, except that cleanout plugs larger than 4" will not be required. Cleanouts installed in connection with cast iron soil pipe shall consist of a long sweep quarter bend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. Floor cleanouts shall be Zurn Figure Z-1324, or equivalent Josam, Wade, or Smith, caulked into the hub of the fitting and finished flush with the floor. Where cleanouts are shown in connection with threaded pipe and are accessible, they shall be cast iron drainage T-pattern, 90-degree branch fittings with square head brass screw plugs of the same size as the pipe, up to and including 4". All outside soil, waste and drain lines shall have two-way cleanouts at all changes of direction.

2.2 EQUIPMENT AND SYSTEM VENTS AND DRAINS:

A. Piping:

1. Piping on closed side of system to match primary system served.

2. Open vent and drain piping of Schedule 40 galvanized steel or Type K or L copper.

B. Valves: Provide valves appropriate for duty.

1. Locate air vent valves accessibly mounted on wall, 5'-0" above floor, extended to drain.

C. Installation Notes:

1. Slope all drains at 1/4" per foot or more.

2. Provide complete condensate drain systems for all air handling units, etc., for all equipment which has a need for such service.

Terminate such drain systems near floor drains, floor sinks or other authorized point of discharge.

2.3 DRAINAGE PIPING SPECIALTIES:

A. VENT FLASHING AND TERMINATION:

1. Vent pipes penetrating the roof shall be flashed and made watertight at the roof with sheet flashing. Flashing shall weigh at least 6 pounds per square foot, shall be square and shall be turned up around the pipe and into the top of the pipe. Vent pipes shall extend at least 12" above roof. Use cast iron flashing clamps for pipe smaller than 3" rather than turning lead into pipe.

B. TRAPS: Each fixture and piece of equipment connecting to the drainage system shall be equipped with a trap. Each trap shall be placed as near to the fixture as possible and no fixture shall be double trapped.

PART III - EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.

C. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.

D. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.

E. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION FOUNDATION FOR UNDERGROUND BUILDING DRAINS:

A. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.

B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.

C. Shape bottom of trench to fit bottom of pipe for 90-degrees (bottom 1/4 of the circumference). Fill unevenness with tamped sand backfill. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

3.3 JOINING PIPES AND FITTINGS:

A. Copper Tubing: Solder joints in accordance with the procedures specified in ANSI B9.1.

B. Cast-Iron Soil Pipe: Make lead and oakum caulked joints, compression joints, and hubless joints in accordance with the recommendations in the CISPI Cast Iron Soil Pipe and Fittings Handbook, Chapter IV.

3.4 INSTALLATION:

A. Refer to the separate Division 22 section: Basic Piping Materials and Methods, for general piping installation instructions.

B. Install supports and anchors in accordance with Division-22 Basic Mechanical Materials and Methods section "Supports and Anchors".

C. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into account many design considerations. So far as practical, install piping as indicated.

D. Make changes in direction for drainage and vent piping using appropriate 45-degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn tees where two fixtures are installed back to back and have a common drain. Straight tees, elbow, and crosses may be used on vent lines. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

E. Install underground building drains to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

F. Install building drain pitched down at minimum slope of 1/4" per foot (2 percent) for

piping 3" and smaller, and 1/8" per foot (1 percent) for piping 4" and larger.

G. Extend building drain to connect to sewer piping, of size and in location indicated for service entrance to building. Sewer piping is specified in a separate section of Division 2.

3.5 INSTALLATION OF PIPING SPECIALTIES:

A. Install flexible connection joints on roof drains.

B. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and:

1. as required by plumbing code;

2. each change in direction of piping greater than 45 degrees;

3. at minimum intervals of 50' for piping 4" and smaller and 100' for larger piping;

4. at base of each vertical soil or waste stack.

C. Cleanout Covers: Install floor and wall cleanout cover for concealed piping, types as indicated.

D. Flashing Flanges: Install flashing flange and clamping device with each stack and cleanout passing through waterproof membranes.

E. Vent Flashing Sleeves: Install on stacks passing through roof, secure over stack flashing in accordance with manufacturer's instructions.

F. Vent Cap: Install on all vents terminating through the sidewall. Secure to vent.

3.6 INSTALLATION OF FLOOR DRAINS:

A. Install floor drains in accordance with manufacturer's written instructions and in locations indicated.

B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.

C. Trap all drains connected to the sanitary sewer.

D. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

E. Position drains so that they are accessible and easy to maintain.

3.7 CONNECTIONS:

A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the plumbing code.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.8 FIELD QUALITY CONTROL:

A. Inspections:

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

3. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.

4. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.

5. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the plumbing official.

6. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test:

1. Test for leaks and defects all new drainage and vent piping systems. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.

2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.

3. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.

4. Prepare reports for all tests and required corrective action.

3.9 ADJUSTING AND CLEANING:

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.10 PROTECTION:

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

3.11 COMMISSIONING: The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 221300

SECTION 221400 – FACILITY STORM DRAINAGE

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 SUMMARY:

A. This Section specifies building sanitary, storm drainage and vent, acid waste and vent and equipment, vent and drain piping systems, including drains and drainage specialties.

B. Related Sections:

1. Separate sections in Division 2 specify sanitary sewage systems and trenching and backfilling. Provide a complete transition between work components.

2. Separate sections in Division 7 specify flashing and sheet metal and joint sealers.

3. Division 22 Plumbing section applies to the work of this section.

4. Separate sections of Division 22 specify Basic Piping Materials and Methods, Hangers and Supports, Expansion Compensation, piping system identification materials and requirements, pipe insulation, and plumbing equipment.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications:

1. Firms regularly engaged in the manufacture of plumbing piping products and equipment of types, materials and sizes required, whose products have been in service for not less than five years.

B. Installer's Qualifications:

1. Firm with at least three years history of successful experience on projects of similar nature.

2. Licensed as a firm in the Contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

4. All workmen employed on the project shall carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer’s technical literature indicating source, brand, type, model, performance characteristics, installation instructions, etc. Color chart for finished surfaces and fixtures.

B. Record Drawings: See Section 15000.

C. Operation And Maintenance Information: Provide information for all equipment including a comprehensive system operating description. See Section 22 01 00.

1.5 REFERENCES:

A. Codes and Standards: Comply with applicable sections, follow recommended practices.

1. State Boiler and Pressure Vessel Regulations
2. ASME Codes for Boilers and Pressure Vessels
3. International Plumbing Code
4. International Building Code
5. International Mechanical Code
6. Americans with Disabilities Act.

1.6 SEQUENCING AND SCHEDULING:

A. Coordinate the installation of roof drains and roof penetrations.

B. Coordinate flashing materials installation of roofing, waterproofing, and adjoining substrate work.

C. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.

D. Coordinate with installation of sanitary sewer systems as necessary to interface building drains with drainage piping systems.

PART II - PRODUCTS

2.1 BUILDING STORM DRAINAGE SYSTEMS:

A. Fixtures and equipment as specified on the drawings and in Specification 15450.

1. Verify drain compatibility with roofing system. Provide options as needed.

2. Verify drain body assembly with roof/deck configuration. Provide adapters, clamps, etc., as needed.

B. Storm Drainage Piping (Non Pressure Rated to 30 Ft. Hd.):

1. Service weight hub and spigot cast iron pipe and fittings with lead caulked or Ty-Seal joints.

2. Service weight "No-Hub" cast iron pipe and fittings with neoprene gaskets and stainless steel screw bands (above ground only).

3. Schedule 40 A53 galvanized steel pipe with drainage pattern cast iron screwed fittings (above ground service only).

4. Cleanouts as for waste piping.

PART III - EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.

C. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.

D. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.

E. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION FOUNDATION FOR UNDERGROUND BUILDING DRAINS:

A. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.

B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.

C. Shape bottom of trench to fit bottom of pipe for 90-degrees (bottom 1/4 of the circumference). Fill unevenness with tamped sand backfill. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

3.3 JOINING PIPES AND FITTINGS:

A. Copper Tubing: Solder joints in accordance with the procedures specified in ANSI B9.1.

B. Cast-Iron Soil Pipe: Make lead and oakum caulked joints, compression joints, and hubless joints in accordance with the recommendations in the CISPI Cast Iron Soil Pipe and Fittings Handbook, Chapter IV.

3.4 INSTALLATION:

A. Refer to the separate Division 22 section: Basic Piping Materials and Methods, for general piping installation instructions.

B. Install supports and anchors in accordance with Division-22 Basic Mechanical Materials and Methods section "Supports and Anchors".

C. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into account many design considerations. So far as practical, install piping as indicated.

D. Make changes in direction for drainage and vent piping using appropriate 45-degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn tees where two fixtures are installed back to back and have a common drain. Straight tees, elbow, and crosses may be used on vent lines. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

E. Install underground building drains to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

F. Install building drain pitched down at minimum slope of 1/4" per foot (2 percent) for piping 3" and smaller, and 1/8" per foot (1 percent) for piping 4" and larger.

G. Extend building drain to connect to sewer piping, of size and in location indicated for service entrance to building. Sewer piping is specified in a separate section of Division 2.

3.5 INSTALLATION OF PIPING SPECIALTIES:

A. Install flexible connection joints on roof drains.

B. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and:

1. as required by plumbing code;

2. each change in direction of piping greater than 45 degrees;

3. at minimum intervals of 50' for piping 4" and smaller and 100' for larger piping;

4. at base of each vertical soil or waste stack.

C. Cleanout Covers: Install floor and wall cleanout cover for concealed piping, types as indicated.

3.6 INSTALLATION OF ROOF DRAINS:

A. Install drains at low points of roof areas as indicated on drawings, in accordance with the roof membrane manufacturer's installation instructions.

B. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining roofing and waterproofing. Maintain integrity of waterproof membranes, where penetrated.

C. Position drains so that they are accessible and easy to maintain.

D. Provide and install flexible connection at connection between drain and piping.

E. Drain grating or top are to be removable to allow for maintenance. Maintenance personnel to use as a cleanout point. All drain bodies to be heavy duty.

3.7 CONNECTIONS:

A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the plumbing code.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.8 FIELD QUALITY CONTROL:

A. Inspections:

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

3. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.

4. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.

5. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the plumbing official.

6. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test:

1. Test for leaks and defects all new drainage and vent piping systems. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.

2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.

3. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.

4. Prepare reports for all tests and required corrective action.

3.9 ADJUSTING AND CLEANING:

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.10 PROTECTION:

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

3.11 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 221400

SECTION 223100 – DOMESTIC WATER SOFTENERS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-22 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 SUMMARY:

A. Extent of water conditioning equipment required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of water conditioning equipment specified in this section include the following:

1. Water Softeners

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of water conditioning equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for chemical treatment and shot feeders.

1.5 REFERENCES:

A. Codes and Standards:

1. ASME Compliance: Manufacture and install chemical treatment in accordance with applicable codes.

PART II - PRODUCTS

2.1 WATER SOFTENERS:

A. General:

B. Manufacturer: Subject to compliance with requirements, provide water softeners of one of the following:

1. Columbia
2. Culligan
3. Intermountain
4. Pure Water Plus

C. Softening System: Twin alternating water conditioning system, with 2" brass top mount control valves, brine tanks and controls to operate on the sodium cycle. The softeners shall be capable of delivering soft water at 74 gpm with a pressure drop not to exceed 15 psig.

D. Mineral Tank: The mineral tanks shall be one-piece construction made of fiberglass reinforced polyester resin. Operating pressure shall be 150 psig at 120^{o}F. The tanks shall be 30" diameter by 60" high.

E. Lower Distribution System: The minimum tank shall be equipped with a PVC hub and lateral lower distributor system. The equally spaced laterals shall have slot openings of 0.010".

F. Media: Each mineral tank shall be provided with seven (7) $ft.^3$ of Ionac C-249 cation exchange resin, having a minimum exchange capacity of 30,000 grains when regenerated with 15 lbs. of salt per cubic foot. The media shall be solid, of proper particle size (not more than 4% through 40 mesh U.S. standard screens, wet screening), and will contain no agglomerates, shells, plates, or other shapes which might interfere with the normal function of the water softeners.

G. Regeneration Control Valve: The softener controls shall be two inches, all brass, top-mount multiport valve, which consists of an assembly of non-sticking, non-leaking water lubricated valve ports that connect to the hard water inlet, soft water outlet, backwash drain, and brine inlet and outlet,, all enclose din a single housing. The control is of adjustable duration for the various steps in service and regeneration. Control of the softener regeneration process shall be fully automatic with no manual assistance, other than replenishment of salt, and shall be initiated by an automatic reset water meter. Regeneration shall be accomplished by the rotation of a shaft that drives the mechanism causing the opening and closing ports in correct sequence. The control also allows for manual regeneration start.

H. Water Meter: Provide a two and one/half (2) inch bronze heavy duty pulse water meter. The meter shall be equipped with a water totalizing register to indicate total water flow through the equipment; it shall also have a flow rate indicator. The meter shall be capable of delivering form .5 to 100 gpm with a +1% accuracy.

Provide the electronic water meter with an end-of-run controller to initiate softener regeneration and transfer of the standby unit into service. The controller shall be a six (6) digit LCD display housed in a NEMA 1 panel. It shall be provided with a battery backup to insure program integrity in the event of power failure.

I. Flow Control: Flow controls for backwash, flush, and brine shall be fully automatic, requiring no field adjustment.

J. Brine Holding/Salt Storage Tank: Provide saturated brine holding tanks constructed of high density polyethylene, 30" diameter by 60" high, holding 800 lbs. of salt. The tanks shall be complete with a polyethylene cover, a combination air check/brine valve, and drain overflow. All brine components shall be constructed of Schedule 80 PVC.

PART III - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which water conditioning equipment is to installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. Install all equipment and components per manufacturer's direction.

B. Provide valved union connecting at all equipment connections.

C. Provide and extend drain lines from all equipment to floor drain or floor sink.

3.3 START-UP AND TEST:

A. Provide factory start-up of all water conditioning equipment.

3.4 SALT:

A. Provide initial loading of salt in the brine tank and additional loading as required to allow for start-up and testing and adjusting of the system.

B. At substantial completion of the job prior to turn over to the owner, provide a full loading of salt in the brine tank.

3.5 COMMISSIONING:

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 223100

SECTION 223436 – COMMERCIAL GAS DOMESTIC WATER HEATERS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the contract, Division 01, etc., apply to the work of this section.

B. Other Division 15 to the extent applicable apply to the work of this section.

1.2 EXTENT OF THE WORK:

A. Provide gas-fired domestic hot water heaters as scheduled and detailed.

B. Provide all supporting installation with flues, gas piping, water piping and valves, relief valves, drains, etc., all required for a complete installation.

1.3 SUBMITTALS:

A. Product Data: Submit information for each water heater and related material and equipment. Include dimensional data. Verify adequate clearance and support service before submitting data.

1.4 REFERENCES:

A. Codes and Standards:

1. Energy Code for commercial and high-rise buildings. (ASHRAE 90.1-1989 Chapter 4). Building Service Systems and Equipment.

   Comply with efficiencies and heat loss requirements of this code.

2. Utah State Plumbing Code, current adopted edition with amendments.

PART II - PRODUCTS

2.1 COMMERCIAL GAS-FIRED WATER HEATERS:

A. General: Provide commercial gas-fired water heaters of sizes and capacities as indicated on schedule. Provide certification of design by AGA under Volume III tests for commercial water heaters for delivery of 180 deg F (82 deg C) water.

B. Manufacturer: Subject to compliance with requirements, provide commercial gas-fired water heaters of one of the following:

1. A. O. Smith Corp.; Consumer Products Div.
2. American Water Heater
3. Rheem

PART III - EXECUTION

3.1 INSTALLATION:

A. Install complete. Place water heater, connect piping with isolation and bypass valving, install relief valves and relief extension, connect to gas service with appliance valve, pressure regulating valve, burner control valve, extend flue and combustion air piping through roof with manufacturer supplied termination kit, provide rated penetration at each floor where required, seismically restrain units to structure.

3.2 FIELD QUALITY CONTROL:

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide start-up service, and demonstrate and train Owner's maintenance personnel as specified below.

1. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.

B. Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

C. Review data in Operating and Maintenance Manuals. Refer to Division 1 Section "Project Closeout."

3.3 COMMISSIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

B. Perform the following before start-up final checks:

1. Fill water heaters with water.
2. Piping systems test complete.
3. Check for piping connections leaks.
4. Check for adequate combustion air.
5. Check for clear vent.
6. Test operation of safety controls and devices.

C. Perform the following start-up procedures:

1. Energize circuits.
2. Adjust operating controls.
3. Adjust hot water outlet temperature setting

END OF SECTION 223436

SECTION 224000 - PLUMBING FIXTURES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division 15, "Basic Mechanical Materials and Methods" sections apply to work of this section.

1.2 SUMMARY:

A. This Section specifies plumbing fixtures and trim. The types of fixtures specified includes the following:

1. Water Closets
2 Urinals
3. Lavatories
4. Work Sink
5. Laundry Sink
6. Service Sinks
7. Electric Water Coolers
8. Hose Bibbs
9. Wall Hydrants
10. Floor Drains
11. Floor Sinks
12. Roof Drains
13. Secondary (Emergency) Roof Drains
14. Downspout Nozzles
15. Cleanouts
16. Trap Primer

1.3 SUBMITTALS:

A. Product Data: Submit Product Data and installation instructions for each fixture, faucet, specialties, accessories, and trim specified; clearly indicate rated capacities of selected models of water coolers.

B. Shop Drawings: Submit rough-in drawings. Detail dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages. Coordinate requirements with fixtures installed in countertops and cabinets. Furnish templates.

C. Color Charts: Submit manufacturer's standard color charts for fixture colors.

D. Maintenance Data: Include data in Maintenance Manual specified in Division 1 and Section 15995.

1.4 REFERENCES:

A. Codes and Standards:

1. ASHRAE Standard 18: "Method of Testing for Rating Drinking Water Coolers with Self-Contained Mechanical Refrigeration Systems".

2. ARI Standard 1010: "Drinking-Fountains and Self-Contained Mechanically-Refrigerated Drinking-Water Coolers."

3. ANSI Standards A117.1: "Specifications for Making Buildings and Facilities Accessible To and Usable By Physically Handicapped People."

4. ADA: Americans with Disability Act.

5. Utah Plumbing Code.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Store fixtures where environmental conditions are uniformly maintained within the manufacturer's recommend temperatures to prevent damage.

B. Store fixtures and Trim in the manufacturer's original shipping containers. Do not stack containers or store in such a manner that may cause damage to the fixture or trim.

1.6 SEQUENCE AND SCHEDULING:

A. Schedule rough-in installations with the installation of other building components.

PART II - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer uniformity shall be as specified in Section 15000, Basic Mechanical Requirements under Project Options.

2.2 FIXTURES:

A. Water Closets: (Flush Valve Type-Wall Mounted)

1. (P-1A) Standard Use Fixture - (1.6 gal./flush, siphon jet)

a. Wall mounted, vitreous china, elongated bowl, top spud.

b. Approved Manufacturers:

(1) Kohler "Kingston" No. K-4430
(2) American Standard "Afwall" No. 2477.016
(3) Crane "Placidus" No. 3-446

2. (P-1B) ADA Compliant Fixture - (1.6 gal./flush, siphon jet)

a. Wall mounted, vitreous china, elongated bowl, top spud. Mounted so top of seat is 18" above finished floor.

b. Approved Manufacturers:

(1) Kohler "Kingston" No. K-4430
(2) American Standard "Afwall" No. 2477.016
(3) Crane "Placidus" No. 3-446

3. (P-1C) ADA Compliant Fixture - (1.6 gal./flush, siphon jet)

   a. Floor mounted, vitreous china, elongated bowl, 3” flush valve tank type. Top of seat to be 17"-19” above finished floor.

   b. Approved Manufacturers:

      (1) Kohler
      (2) American Standard
      (3) Crane

4. Flush Valve - (1.6 gal./flush) - Standard and ADA Use Fixture

   a. Chrome plated, vacuum breaker, screwdriver stop, level operated.

   b. Approved Manufacturers: (Typical for standard and ADA fixtures)

      (1) Sloan - "Royal" No. 111-YO-3
      (2) Zurn - "Aquaflush" No. Z-6000XL
      (3) Delany - "Flushboy" No. 402-JVB

5. Seat -

   a. (White) high impact plastic, open front, check hinge.

   b. Approved Manufacturers: (Typical on standard use and ADA fixtures)

      (1) Church No. 295C
      (2) Beneke No. 527CH
      (3) Bemis No. 1655-C
      (4) Olsonite No. 95

B. Urinals:

1. (P-2A) Standard Use Fixture

   a. Wall mounted, vitreous china, siphon jet, 3/4" top spud, 2" outlet. Mount so rim is 24" A.F.F.

   b. Approved Manufacturers:

      (1) Kohler "Freshman" No. K-4989-T
      (2) American Standard "Trimbrook" No. 6561.017
      (3) Eljer "Savon" No. 161-1090
      (4) Crane "Embassy" No. 7-150

2. (P-2B) ADA Fixture

   a. Wall mounted, vitreous china, siphon jet, 3/4" top spud, 2" outlet. Mount so rim is 14" A.F.F.

   b. Approved Manufacturers:

      (1) Kohler "Freshman" No. K-4989-T
      (2) American Standard "Trimbrook" No. 6561.017

(3) Eljer "Savon" No. 161-1090
(4) Crane "Embassy" No. 7-150

3. Flush Valve - Standard and ADA Use Fixture

a. Polished chrome plated, vacuum breaker, screwdriver stop, battery powered, sensor operated.

b. Approved Manufacturers:

(1) Zurn “AquaSense” No. ZR-6000XL
(2) Delany “Impulse” No. I-1452-1.
(3) Sloan “Optima Plus” No. 8186.

C. Lavatory:

1. (P-3) ADA Fixture

a. Wall mounted, 18" x 20", vitreous china, front overflow, faucet holes on 4" centers, concealed arm carrier, mounted so bottom of lavatory is 29" above finished floor, furnish and install pre-formed insulation around P-trap and water supplies meet 25/50 flame/smoke rating.

b. Approved Manufacturers:

(1) Kohler "Kingston" No. K-2005
(2) American Standard "Lucerne" No. 0355.012
(3) Eljer “Delwyn” No. 051-1644.
(4) Crane “Harwich” No. 1-412-V.

2. Faucet (P-3):

a. Battery powered sensor operated faucet. Chrome plated brass spout, complete with sensor module, batteries, 0.5 gpm vandal resistant aerator, chrome plated brass cover plate, temperature mixing valve with integral backflow check valves.

a. Approved Manufacturers:

(1) Zurn “AquaSense” No. Z-6910-CP4
(2) Speakman “Microflo” No. ECM-1010

3. Pre-formed Insulation and Protective Cover: (P-3)

a. Pre-formed foam or fiberglass insulation with two piece white PVC snap on cover with velcro closure, to fit 1-1/4" P-trap and 3/8" hot water stop and supply, meet 25/50 flame/smoke rating.

b. Approved Manufacturer:

(1) Buckaroos, Inc.
(2) Truebro
(3) or an engineer approved equivalent.

4. Supplies with Stops: (P-3)

a. Chrome plated with hand wheel, chrome escutcheons.

b. Ball type.

c. Approved Manufacturers:

(1) Brass Craft
(2) Eastman
(3) McGuire

5. P-Trap: (P-3)

a. 17 gauge, tubular brass, chrome plated and chrome escutcheons.

b. Approved Manufacturers:

(1) Dearborn
(2) McGuire
(3) Jameco
(4) Sanitary Dash

6. Strainer: (P-3)

a. Drain with grid pattern strainer, cast brass, chrome plated. Provide offset type drain as required to maintain ADA clearances.

b. Approved Manufacturers:

(1) Kohler
(2) Jameco
(3) Sanitary Dash
(4) McGuire

D. Work Sink:

1. (P-4A), (P-4B) and (P-4C) Fixture:

a. Double compartment, counter mounted, 18 gauge type 304 stainless steel, 3 faucet holes on 4" centers, self-rimming, sound deadened.

b. Approved Manufacturers:

(1) Just No. DL-2133-A-GR.
(2) Elkay No. LR-3322.

2. Faucet: (P-4A), (P-4B) and (P-4C)

a. Underdeck mounted, 8" high rigid gooseneck spout, 2.5 gpm vandal proof aerator, 4" wing handles, supplies on 8" centers.

b. Approved Manufacturers:

(1) Chicago Faucet No. 786-GN2A-E3VP
(2) T & S Brass

3. Supplies and Stops: (P-4A), (P-4B) and (P-4C)

a. Chrome plated with hand wheel, chrome escutcheons.

b. Ball Type.

c. Approved manufacturers:

(1) Brass Craft
(2) Eastman
(3) McGuire

4. Outlet Fitting and Tailpiece: (P-4A), (P-4B) and (P-4C)

a. Chrome plated strainer stopper combination assembly.

b. Approved Manufacturers:

(1) Just No. J35.
(2) Elkay No. LK99

5. P-Trap: (P-4A), (P-4B) and (P-4C)

a. 17 gauge, tubular brass, cleanout plug, chrome plated and chrome escutcheons.

b. Approved Manufacturers:

(1) Dearborn
(2) McGuire
(3) Jameco
(4) Sanitary Dash

6. Disposal: (P-4B) Only

E. Laundry Sink:

2. (P-4D) Fixture:

a. Single Compartment, free standing, seamless welded construction of 14 gauge, type 304 stainless steel (including legs with frame).

b. Approved Manufacturers:

(1) Just No. J-127
(2) Elkay

3. Faucet:

a. Wall-mounted mixing faucet, bucket hook, vacuum breaker, top brace, integral stops in shanks, polished chrome finish.

b. Approved Manufacturers:

(1) Kohler No. K-8904.
(2) Chicago Faucet

4. Supplies and Stops: (P-4D)

   a. Chrome plated with hand wheel, chrome escutcheons.

   b. Ball Type.

   c. Approved manufacturers:

      (1) Brass Craft
      (2) Eastman
      (3) McGuire

5. Outlet Fitting and Tailpiece: (P-4D)

   a. Chrome plated strainer stopper combination assembly.

   b. Approved Manufacturers:

      (1) Just No. J35.
      (2) Elkay No. LK99

6. P-Trap: (P-4D)

   a. 17 gauge, tubular brass, cleanout plug, chrome plated and chrome escutcheons.

   b. Approved Manufacturers:

      (1) Dearborn
      (2) McGuire
      (3) Jameco
      (4) Sanitary Dash

F. Service Sink:

1. (P-5) Fixture:

   a. Floor mounted, enameled cast iron, vinyl coated rim guard.

   b. Approved Manufacturers:

      (1) Kohler "Whitby" No. K-6710.
      (2) CECO

2. Faucet:

   a. Wall-mounted mixing faucet, bucket hook, vacuum breaker, top brace, integral stops in shanks, polished chrome finish, mount so inlets are 36" above finished floor. Provide 5 ft. of 3/4" commercial grade rubber hose with male and female connectors.

   b. Approved Manufacturers:

      (1) Kohler No. K-8904.
      (2) Chicago Faucet

3. Outlet:

a. 3" threaded outlet and chrome plated flat metal grid strainer with cleanout plug.

b. Approved Manufacturers:

(1) Kohler No. 9146.
(2) American Standard No. 7721.038.
(3) Eljer No. 830-0630.

4. P-Trap:

a. 3" cast iron.

G. Electric Water Cooler:

1. (P-6A) Standard and ADA Compliant Fixture:

a. Self-contained, wall-hung, bi-level unit with one fixture mounted so spout is no higher than 42" above finished floor and the second fixture mounted so spout is 36" above finished floor, self-contained, front and side pressure operator with cast brass bubbler, air cooled, 7.8 gal. per hour capacity (minimum), with 90^{o} ambient air, water entering at 80^{o} and leaving at 50^{o}, stainless steel top, stainless steel cabinet. 5 year warranty, 120 volt, 60 cycle, 1 phase power.

(1) Approved Manufacturers:

(a) Elkay No.
(b) Oasis
(c) Halsey-Taylor

2. Supply and Stop:

a. Chrome plated with hand wheel, chrome escutcheons.

b. Ball Type.

c. Approved Manufacturers:

(1) Brass Craft
(2) Eastman
(3) McGuire

3. P-Trap:

a. PVC with chrome escutcheons.

b. Approved Manufacturers:

(1) Dearborn
(2) McGuire
(3) Jameco
(4) Sanitary Dash

4. (P-6B) ADA Compliant Fixture:

a. Self-contained, wall-hung, self-contained, front and side pressure operator with cast brass bubbler, air cooled, 7.8 gal. per hour capacity (minimum), with 90^{o} ambient air, water entering at 80^{o} and leaving at 50^{o}, stainless steel top, stainless steel cabinet. 5 year warranty, 120 volt, 60 cycle, 1 phase power.

(1) Approved Manufacturers:

(a) Elkay No.
(b) Oasis
(c) Halsey-Taylor

H. (P-7A) and (P-7B) Shower:

1. Fixture:

a. Shower Valve to be thermostatic mixing type valve, lever handle, ADA compliant, check stops, hand shower, adjustable 2.5 gpm shower head, arm, flange in-line diverter and in-line vacuum breaker. Delete hand shower and in-line diverter for (P-7) units.

b. Approved manufacturers:

(1) Powers No. e426EK16YW
(2) Symmons
(3) Leonard

2. (SD-1) Shower Drain:

a. Cast iron body, 6" diameter, polished nickel bronze grate, clamping collar, 40 mil “Pasco” PVC shower drain pan under shower base, 2" outlet and P-trap.

b. Approved manufacturers:

(1) Zurn No. ZN-415Y
(2) Smith
(3) Josam
(4) Wade No. W-1100-G

I. (P-8) Clothes Washer Connection Box:

1. Fixture:

a. Washer connection box with ball type shut-off valve, 2" outlet to standpipe, flush mounted.

b. Approved Manufacturer:

(1) Guy Gray with Watts “Duo Cloz” valve
(2) Specialty Products Company

J. (P-9) Ice Maker Connection Box:

1. Fixture:

a. Water connection box with ball type shut-off valve, flush mounted.

b. Approved Manufacturer:

(1) Specialty Products
(2) Guy Gray

K. Hose Bibb:

1. (HB-1) and (HB-2) Fixture:

a. Chrome plated brass, removable key, vacuum breaker, 3/4" inlet and outlet, provide isolation valve upstream of bibb.

b. Approved Manufacturers:

(1) Chicago No. 998
(2) T & S Brass

L. Non-Freeze Wall Hydrant:

1. (WH) Fixture:

a. Bronze hydrant, exposed type removable key, vacuum breaker, automatic draining, stainless steel operating stem, rough brass finish.

b. Approved Manufacturers:

(1) Woodford No. 65

M. Floor Drain 1:

1. (FD-1) Fixture:

a. 5" diameter nickel bronze strainer, cast iron body with 2" outlet and P-trap, clamping collar. Provide with trap primer connection where shown on drawings.

b. Approved Manufacturers:

(1) Zurn No. ZN-415.
(2) J.R. Smith No. 2010
(3) Josam No. 30000-A
(4) Wade No. 1100 Series

N. Floor Drain 2:

1. (FD-2) Fixture:

a. 4” x 12”, rectangular nickel bronze strainer, cast iron body with 2" outlet and P-trap, clamping collar.

b. Approved Manufacturers:

(1) J.R. Smith No. 2010-M
(2) Josam No. 30000-R
(3) Wade No. 1100-H
(5) Zurn No. ZN-415-J.

N. Floor Sink:

1. (FS-1) and (FS-2) Fixture:

a. 12" diameter floor sink, cast iron body and square slotted medium duty grate, (refer to plans for grate requirements, ie. 1/2, 3/4, Full, None) with white acid resisting porcelain enamel interior and top, complete with aluminum anti-splash bottom dome strainer, 8" deep sump with bottom outlet and P-trap. Size as indicated on drawings.

b. Approved Manufacturers:

(1) Zurn No. Z-1950
(2) J.R. Smith
(3) Josam
(4) Wade

O. Roof Drain:

1. (RD) Fixture:

a. Cast iron body, bottom outlet, aluminum or cast iron dome with locking screws, roof sump receiver, bearing pan, under deck clamp, extension as required, 4 lb. lead pan for installation by roofer. See plumbing plan for outlet sizes.

b. Approved Manufacturers:

(1) Zurn No. Z-121
(2) Wade Series 3000
(3) Josam No. 21500
(4) J.R. Smith No. 1310

P. Overflow (Emergency) Roof Drain:

1. (ORD) Fixture:

a. Same as RD, with exception of being mounted so top of drain body is 2" higher on the roof, see plans.

b. Approved Manufacturers:

(1) (See RD)

Q. Cleanouts:

1. Finished Floors:

a. Approved Manufacturers:

(1) Zurn No. Z-1400-2
(2) J.R. Smith No. 56010
(3) Wade No. W-7000
(4) Josam No. 56010

2. Finished Walls:

a. Approved Manufacturers:

(1) Zurn No. Z-1445-1
(2) J.R. Smith No. 4530
(3) Wade No. W-8460-R
(4) Josam No. 58790

R. Trap Primers:

1. (TP-1) Fixture:

a. Fully automatic, all brass trap primer valve, activated by a drop in building water pressure, no adjustment required, for one (1) to four (4) traps with distribution unit..

b. Approved Manufacturers:

1) PPP Inc. Model PR-500
2) Sioux Chief

PART III - PLUMBING FIXTURES

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all plumbing fixtures may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Examine rough-in for potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.

C. Examine floors, floors, and cabinets for suitable conditions where fixtures are to be installed.

D. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturer's written instructions, rough-in drawings, and pertinent codes and regulations, the original design, and the referenced standards.

B. Comply with the installation requirements of ANSI A117.1 and Public Law 90-480 with respect to plumbing fixtures for the physically handicapped.

C. Fasten plumbing fixtures securely to supports or building structure. Secure supplies behind or within wall construction to provide rigid installation.

D. Install a stop valve in an accessible location in the water connection to each fixture.

E. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork.

F. Seal fixtures to walls and floors using silicone sealant. Match sealant color to fixture color.

3.3 FIELD QUALITY CONTROL:

A. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, the retest. Also test for rigidity of fixtures hung on carriers, flush valves, etc.

B. Inspect each installed unit for damage. Replace damaged fixtures.

3.4 ADJUSTING:

A. Adjust water pressure at drinking fountains, faucets and flush valves to provide proper flow stream.

B. Replace washers of leaking or dripping faucets and stops.

3.5 CLEANING:

A. Clean fixtures, trim, and strainers using manufacturer's recommended cleaning methods and materials.

3.6 PROTECTION:

A. Provide protective covering for installed fixtures, water coolers, and trim.

B. Do not allow use of fixtures for temporary facilities unless expressly approved in writing by the Owner.

3.7 COMMISSIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 01 08-00 – Commissioning General Requirements and Section 22 08 00, Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 224000

INDEX

DIVISION 23 – MECHANICAL

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Section 230505 Mechanical Firestopping
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Section 230519 Thermometers and Pressure Gauges
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SECTION 230000 - GENERAL MECHANICAL REQUIREMENTS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

Sections of other Divisions which relate to mechanical work apply to the work of this section. See various Sections on sitework, underfloor work, structural work, finish materials, etc.

B. Related Sections: Refer to “Electrical Requirements for Mechanical Equipment” Section in Division 23 for basic electrical requirements for all mechanical equipment. Special and specific electrical requirements are specified within each respective equipment specification section.

1.2 SUMMARY: This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 23. It expands and supplements the requirements of Division 01.

This Division does not define, nor is it limited by, trade jurisdictions. All work described herein is a part of the General Contract and is required of the Contractor regardless.

1.3 DESCRIPTION OF PROJECT: The mechanical work described in these mechanical specifications is for a project located at Camp Williams, Utah. Design weather conditions are: 95^{o} db, 62^{o} wb, and winter 3^{o}F. Altitude readings, unless otherwise noted, are for an elevation of 4,500 feet above sea level. Make adjustment to manufacturer's performance data as needed.

1.4 CODES AND PERMITS, AUTHORITIES HAVING JURISDICTION:

A. Perform the mechanical work in strict accordance with the applicable provisions of the various codes ordinances and adoptions pertaining to the project location in effect on the date of invitation for bids. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications govern.

B. Hold and save the Owner and Architect/Engineer free and harmless from liability of any nature or kind arising from failure to comply with codes and ordinances.

C. Secure all permits necessary for the prosecution of the work under this contract. Owner to pay all fees including connection fees related to utility hookups.

D. Reference Standards:
American Welding Society
International Mechanical Code/State Code
International Building Code/State Code
SMACNA Duct Design Standards
Local/State Plumbing Code
Locally enforced NFPA Codes
Local Fuel Utility Regulations
Local Power Utility Regulations
American Gas Association
ASME Codes for Pressure Vessels and Piping
ANSI B31.1 Piping

E. Final inspection by the Architect/Engineer will not be made nor Certificate of Substantial Completion issued until certificates of acceptability from the Authorities having jurisdiction are delivered.

1.5 DEFINITION OF PLANS AND SPECIFICATIONS: The mechanical drawings at reduced scale show the general arrangement of piping, ductwork, equipment, etc., and shall be followed as closely as the actual building construction and the work of other trades will permit. The architectural and structural drawings shall be considered as part of the work insofar as these drawings furnish the Contractor with information relating to design and construction of the building. Architectural drawings shall take precedence over mechanical drawings. Request clarification and participate in resolution in the event of conflict.

Because of the small scale of the mechanical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing such extensions, fittings, valves and accessories to meet the conditions as may be required. Some small scale work is not shown such as control conduit and piping, incidental piping, specialties. Provide as directed by note or specification.

Examine the actual construction site prior to bidding and obtain an understanding of the conditions under which the work will be performed. No allowances will be made for failure to make such examination.

During construction, verify the dimensions governing the mechanical work at the building. No extra compensation shall be claimed or allowed because of differences between actual dimensions and those indicated on the drawings. Examine adjoining work on which mechanical work is dependent for perfect efficiency, and report any work of other trades which must be corrected. No waiver of responsibility for defective work shall be claimed nor allowed due to failure to report unfavorable conditions affecting the mechanical work.

1.6 ROUGH-IN:

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 02 through 35 for rough-in requirements.

1.7 MECHANICAL INSTALLATIONS:

A. Coordinate mechanical equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.

D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

F. Coordinate the cutting and patching of building components to accommodate installation

of mechanical equipment and materials.

G. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

H. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

I. Coordinate the installation of mechanical materials and equipment above ceilings with suspension systems, light fixtures, existing structures and other installations.

J. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

K. Where mechanical work penetrates other trade work such as gypboard walls, etc., penetration shall be neatly cut and walls shall be filled and patched.

1.8 ACCESSIBILITY:

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

B. Extend all grease fittings to an accessible location where maintenance personnel have space to operate a grease gun.

C. Establish required clearance to all installation features involving operation and maintenance. Respect manufacturers recommendations for access and clearance.

D. Access Doors - General: All items of mechanical equipment which may require adjustment, maintenance, replacement or which control a system function shall be made readily accessible to personnel operating the building.

1. Provide access doors in all ductwork or plenums as required to maintain fire dampers, fire smoke dampers, equipment, controls or other elements of the system. Doors shall conform to SMACNA standards unless otherwise detailed or specified. Refer to Section 23 33 00 for sizes.

2. Provide access doors in floors, walls, ceiling and partitions to valves, cleanouts, chases, dampers, etc., and to access doors in ductwork requiring the same. Access doors shall be all-steel construction equivalent to "Milcor" by Inland Ryerson in a style approved by the Owner's Representative. Doors shall be 24" x 24" minimum, or larger as needed, with screwdriver latches.

1.9 CHANGE ORDERS: See General Conditions.

1.10 ALTERNATIVE CONSTRUCTION/SUBSTITUTION: These documents outline a way in which the Owner may be delivered a functional and reliable facility. Drawings and specifications describe reasonable engineering practice for the Contractor to follow.

Coordination between trades may result in periodic needs to adjust the installation from that

indicated, but in no case shall the intended function be compromised.

The Contractor may perceive some work methods which differ from those specified which could save time and effort. These may be presented to the Architect with a breakdown of possible cost savings for review. Implement only with authorization.

Materials substitutions will generally be covered in a review process prior to bidding. After bidding, substitutions shall be proposed only on the basis of definitive cost accounting and implemented only with authorization.

1.11 CUTTING AND PATCHING:

A. Lay out the project where new work is involved ahead of time, providing sleeves and blockouts, and have work specifically formed, poured and framed to accommodate mechanical installations. Cut and patch only as needed.

B. Refer to the Division 01 Section: CUTTING AND PATCHING for general requirements for cutting and patching.

C. Refer to Division 26 Section: BASIC ELECTRICAL REQUIREMENTS for requirements for cutting and patching electrical equipment, components, and materials.

D. Do not endanger or damage installed Work through procedures and processes of cutting and patching.

E. Arrange for repairs required to restore other and any work damaged as a result of mechanical installations.

F. No additional compensation will be authorized for cutting and patching Work that is necessitated by ill-timed, defective, or non-conforming installations.

G. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work;

2. Remove and replace defective Work;

3. Remove and replace Work not conforming to requirements of the Contract Documents;

4. Remove samples of installed Work as specified for testing:

5. Install equipment and materials in existing structures.

H. Upon written instructions from the Architect/Engineer, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

I. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping and other mechanical items made obsolete by the new Work.

J. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

K. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of

dust and dirt to adjacent areas.

1.12 SUBMITTALS: Submittal of shop drawings, product data, and samples will be accepted only from the Contractor to the Architect. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed. Document each transmittal and sign and stamp the submittal indicating that it has been reviewed and is in compliance with the criteria of the project, any exceptions being clearly noted.

A. Shop Drawings: As soon as possible after the contract is awarded, submit to the Architect, seven (7) copies of the descriptive literature covering all equipment and materials to be used in the installation of mechanical systems for this project. Written confirmation of acceptable review by the Owner's Representative shall be obtained before ordering, purchasing, acquiring or installing any such equipment or materials for the project.

Prepare the submittals in an orderly manner after the order of this specification, contained in a three-ring looseleaf binder(s) with identification tabs for each item or group of related items. Submitted literature shall clearly indicate performance, quality, utility requirements, dimensions of size, connection points and other information pertinent to effective review.

Equipment must fit into the available space with allowance for operation, maintenance, etc. The Contractor shall take full responsibility for space and utility requirements for equipment installed.

Factory-wired equipment shall include shop drawings of all internal wiring to be furnished with unit.

Review of the Architect/Engineer is for general conformance of the submitted equipment of the project specification; in no way does such approval relieve Contractor of his obligation to furnish equipment and materials that comply in detail to the specification, nor does it relieve the Contractor of his obligation to determine actual field dimensions and conditions which may affect his work.

B. Record Drawings: During the course of construction, maintain a set of drawings, specifications, change orders, shop drawings, addenda, etc., for reference and upon which all deviations from the original layout are recorded. Turn these marked-up documents over to the Architect/Engineer at the conclusion of the work so that the original tracings can be revised. If the Contractor fails to mark up the prints, reimburse the Architect/Engineer for time required to do so.

1.13 OPERATION AND MAINTENANCE TRAINING:

A. Instruction Of Owner's Personnel: At a time prior to Owner making use of a device or system, and in general after testing and balance work for a building or major system is complete, prepare, schedule and conduct a series of training sessions for Owner's operating and supervisory personnel. Instructions shall cover each device and system with emphasis on understanding of the purpose and function, the maintenance requirements and the proper adjustment and operating technique.

B. Instruct building operating staff in operation and maintenance of mechanical systems utilizing Operation and Maintenance Manual when so doing.

C. Minimum instruction periods shall be as follows:

1. Mechanical - ten hours, total.

2. Temperature Control - ten hours, total. Programming help as needed.

D. Initial instruction periods shall occur after pre-final inspection when systems are properly working and before final payment is made. Schedule subsequent visits with the Owner's Building Operation Personnel throughout the first year.

E. None of these instructional periods shall overlap another.

F. Vendors for each piece of equipment controls, etc., shall participate along with the Contractor(s).

1.14 GUARANTEE/WARRANTY: The following guarantee is a part of this specification and is binding on the part of the Contractor and his assigns:

"Contractor guarantees that this installation is in accordance with the terms of the Contract and is free from mechanical defects. He agrees to replace or repair, to the satisfaction of the Owner's Representative, any part of this installation which may fail or be determined unacceptable within a period of one (1) year after final acceptance. See also the General Conditions of these specifications. Failed equipment in the repair or replacement shall be guaranteed for one full year from the date of recommission."

Compile and assemble the warranties required by Division 23 into a separated set of vinyl covered, insert sheets, tabulated and indexed for each reference, included in the O & M Manual.

Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

Mechanical systems and equipment shall not be considered for substantial completion and initiation of warranty until they have performed in service continuously without malfunction for at least thirty (30) working days.

1.15 TESTS AND CERTIFICATIONS: Make all tests required by code or specification in the presence of a representative of the Owner, with tests recorded and certified by the Contractor and Representative. Involve local authorities where required.

1.16 PERMITS, FEES, LICENSES: Refer to General Conditions. See Paragraph 1.4.

1.17 CEILING SPACE COORDINATION: Carefully coordinate ceiling cavity space with all trades; however, installation of mechanical equipment within the ceiling cavity space allocation, in the event of conflict, shall be in the following order: plumbing waste lines; supply, return and exhaust ductwork; domestic hot and cold water; fire protection; control conduit. Respect clearances required for lights, electrical conduits, protected structure, etc. All spaces above any and all ceilings shall be defined and considered as return air plenum space.

1.18 MECHANICAL COORDINATION DRAWINGS: For the fan rooms, chiller room, high temperature water converter room, congested areas, or areas of great detail, prepare and submit a set of coordination drawings showing major elements, components and systems of mechanical equipment and materials in relationship with other building components (structure, fire sprinkler, electrical, etc.). Prepare drawings to an accurate scale of 1/4" - 1-0" or larger. Indicate the locations of all equipment and materials, including clearances for installing and maintaining equipment, servicing and maintaining equipment, valve stem movement, and similar requirements. Indicate movement and positioning of large equipment into the building during construction.

Prepare floor plans, reflected ceiling plans, elevations, sections and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the work, including (but not necessarily limited to) the following:

A. New fan rooms and mechanical rooms:

1. Supply and relief air fans, plenums, etc.
2. Cooling coils, heating coils, filters, etc.
3. Relief Fans.
4. Chillers.
5. Boilers.
6. Pumps.
7. Glycol Make-Up Unit.
8. Piping, expansion tanks.
9. Water Softeners
10. Chemical Treatment units.
11. Specialty systems.
12. Electrical installations.
13. Related structure.

B. Work in pipe spaces, chases, trenches, and tunnels.

C. Exterior wall penetrations.

D. Ceiling and floor plenums which contain piping, ductwork, or equipment in congested arrangement. To include structure, ductwork, piping, fire protection, large electrical conduit, recessed lights, etc.

E. Installations in mechanical riser shafts, at typical sections and crucial offsets and junctures.

F. Pipe expansion loops.

G. Numbered valve location diagrams.

H. Exterior underground lines in common excavation.

I. Manifold piping for multiple equipment units.

J. General floor plan layouts with ductwork, piping, lighting, structure, etc.

K. Use drawings to coordinate all affected trades. Do not work without coordinated drawings.

1.19 SCHEDULING/METHODS OF PROCEDURE: Where interruptions of service are needed to effect work of this contract, outline the work, coordinate with other trades, determine the Owners acceptable downtime and prepare a time based schedule to accomplish the work. Give notice of a necessary utility interruption (or shutdown) to any existing system to the owner's construction coordinator not less than 72 hours prior to the proposed shutdown. This will then be coordinated with the Base Utility Services Department and the areas involved for approval to go ahead with the shutdown or re-schedule. Set up for evening, nighttime or weekend hours as necessary to accomplish the work with minimum disruption.

PART II - GENERAL MECHANICAL MATERIALS AND METHODS

2.1 QUALITY OF MATERIALS AND EQUIPMENT:

A. All equipment and materials shall be new, except for the existing equipment being relocated from the Cannon Center and shall be the standard products of manufacturers regularly engaged in the production of plumbing, heating, ventilating and air conditioning equipment, and shall be the manufacturer's latest design. Specific equipment shown in schedules on drawings and specified herein is to be the basis for the Contractor's bid. Provisions for substitute equipment are outlined in the General Conditions. All materials shall be produced by manufacturing plants located in the United States of America.

B. Furnish and install all major items of equipment specified in the equipment schedules on the drawings complete with all accessories normally supplied with catalog items listed, and all other accessories necessary for a complete and satisfactory installation.

2.2 PROTECTION OF MATERIALS AND EQUIPMENT:

A. Close pipe and duct openings with caps or plugs to prevent lodgement of dirt or trash during the course of installation. Cover equipment tightly and protect against dirt, water and chemical or mechanical injury. Plumbing fixtures intended for the final installation shall not be used by the construction forces. At the completion of the work, clean fixtures, equipment and materials and polish thoroughly and deliver in a factory dock condition for the Owner's acceptance. Make damage and defects developing before acceptance of the work good at Contractor's expense.

B. Do not make temporary use of project equipment, new or existing, during construction without the written consent of the owner. Systems shall not be used for temporary heat.

2.3 QUALIFICATIONS OF WORKMEN:

A. All mechanics shall be capable journeymen, skilled in the work assigned to them. Apprentices may be used with appropriate direction.

B. Employ no unskilled persons in the work which he is given to do; execute all work in a skillful and workmanlike manner. All persons employed upon this work shall be competent, faithful, orderly and satisfactory to the Owner. Should the Owner's Representative deem anyone employed on the work incompetent or unfit for his duties, and so certify, Contractor shall dismiss him and he shall not be again employed upon the work without permission of the Owner's Representative.

C. All welders involved in welding of pressure piping systems shall be certified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. Written verification of successful test completion shall be submitted to Architect prior to initiating work.

2.4 FOREMAN: Dedicate and designate a full-time general mechanical foreman to the Owner's Representative to be consistently available on site during the life of the project for consultation. Do not replace this individual without prior approval from the Owner's Representative.

2.5 USE OF COMMON VENDORS: Regardless of subcontract delegations, coordinate purchasing between trades so that equipment and materials of similar nature come from a single vendor, i.e., all package HVAC terminal units shall be common source. Valves, terminal boxes, speed drives, etc., the same. Do not burden the Owner with multiple brands of similar equipment unless so directed.

2.6 ROOF/WALL/FLOOR PENETRATIONS - FLASHINGS:

A. Install sleeves through the floor into “dry rooms” flush with the floor, caulked and sealed. Into wet rooms, extend piping to create 1" dam. Use Schedule 40 galvanized steel pipe for all pipe sleeves.

B. Let pipe sleeves allow for movement of the pipe due to expansion and contraction, yet to include seismic restraint.

C. Refer to Section “FIRE STOPPING” for requirements.

D. Flashings:

1. Flash all pipes penetrating the roof. Provide required flashing components.

2. Clamp roof drains to roof membrane, follow manufacturer's directions.

3. Flash and counterflash other piping penetrating the roof. See drawings or Architect/Engineer for additional detail.

2.7 EXCAVATING AND BACKFILLING (GENERAL):

A. Provide all excavation, trenching and backfilling for Division 23 underground piping work. Excavation and backfilling shall comply with applicable paragraphs of Division 31. Tamp bottoms of trenches hard and, for soil and waste piping, grade to secure uniform fall of 1/4" per foot, or as noted. Excavate bell holes for hub and spigot pipes so that pipe rests on solid ground for its entire length. Lay sewer and water pipe in separate trenches, except where otherwise noted, as detailed.

B. After work has been tested, inspected and approved by the Owner's Representative and/or State/Local Inspector, and prior to backfilling, clean the excavation of all rubbish, and clean backfill materials free of trash. Place backfill in horizontal layers not exceeding 12" in thickness, properly moistened. Mechanically compact each layer with suitable equipment to a dry density of not less than 95 percent as determined by the Modified AASHO Test T-18O. See Division 31 for additional requirements.

1. Provide adequate shoring to safeguard workers from cave-ins for all excavations.

a. In areas where General Contractor has finish grade work to do, Mechanical Contractor shall backfill and compact to 8" below finish grade. Where no finish surface work is to be done, Mechanical Contractor shall backfill and compact to and match adjacent undisturbed surface with allowance for settling, etc.

2. Protect from damage all existing underground utilities or utility tunnels indicated on the contract drawings (or field located for the Contractor by the Owner prior to excavation operations). Any damage to identified existing utilities or utility tunnels shall be repaired by the Contractor at no cost to the Owner.

2.8 HANGERS AND SUPPORTS (GENERAL):

A. Provide hangers and/or supports for all equipment, piping and ductwork. Primary information is contained in these specifications and on the drawings.

B. Provide hangers and supports to correlate with seismic restraint and vibration isolation.

2.9 MANUFACTURER'S DIRECTIONS: Install all equipment in strict accordance with directions and recommendations furnished by the manufacturer. Where such directions are in conflict with the plans and specifications, report such conflicts to the Architect who shall direct adjustments as deemed necessary and desirable.

2.10 LUBRICATION: Lubricate equipment at startup. Then, provide all lubricants for the operation of all equipment until acceptance by the Owner. The Contractor is held responsible for all damage to equipment and bearings while the equipment is being operated by him consequent to preacceptance operation.

2.11 ELECTRICAL WIRING AND CONTROL:

A. In general, motor starters, related motor starter equipment and power wiring indicated on the electrical drawings and control diagrams are to be furnished and installed under Division 26 of this Specification. Items of electrical control equipment specifically mentioned to be furnished by the Division 23 either in these specifications or on the electrical or mechanical drawings, shall be furnished and mounted by this Contractor and shall be connected under and as required by this Division 23 and Division 26 of these specifications.

B. Refer to the control equipment and wiring shown on the diagrams. Any changes or additions required by specific equipment furnished shall be the complete responsibility of the contractor.

C. Division must be fully coordinated with Division 26 to insure that all required components of the work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of coordination.

D. Where the detailed electrical work is not shown on the electrical drawings, the Mechanical Contractor shall furnish, install and wire or have prewired all specified and necessary controls for air handling equipment specified for this project. The objective of this paragraph is to make sure a complete operating system is obtained at no additional cost to the Owner for field wiring required related to the equipment.

2.12 FLUSHING AND DRAINING OF SYSTEMS/CLEANING OF PIPING AND DUCTS: Fill, clean and flush and sterilize where appropriate, all water piping systems with water and drain these systems before they are placed in operation. Flushings shall consist of not less than six (6) short, intermittent flushes of five (5) to ten (10) minutes duration. Sample and test each flush for cleanliness.Blow out all other piping systems with compressed air or nitrogen to remove foreign materials that may have been left or deposited in the piping system during its erection. Duct systems shall have all debris removed and fans shall be run to blow out all dust and foreign matter before grilles, outlets or mixing boxes are installed and connected.

Damp wipe all ductwork on installation, cap open ducts, cover fan inlets, vacuum fan plenums and related installation before starting fans. Run fans only with filters in place.

2.13 JOBSITE CLEANUP:

A. Keep site clean during progress of work.

B. At the conclusion of work, clean all installation thoroughly.

1. Leave equipment in a factory dock condition. Correct any damage and touch up or repaint if necessary.

2. Remove all debris from site.

2.14 ARCHITECTURAL ACCESS DOORS:

A. Extent of Work: Provide architectural grade access doors at each point of required access to duct features, piping valves, and specialties, concealed equipment, etc. Coordinate this work with other sections for ceilings, walls, etc.

B. Material: Steel framed doors with heavy duty hinges and latch type locking mechanisms with surface finish configuration to accept, match or correlate with adjacent surface.

1. Product equivalent to Inland-Ryerson “Milcor”, Cesco

2. Size adequate to access point of maintenance, to work on and remove concealed devices and equipment.

C. Installation: Complete, blended into adjacent work.

PART III – EXECUTION

3.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230000

SECTION 230100 - OPERATION AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specifications sections, apply to work of this section.

B. Division-23 General Mechanical Requirements sections apply to work of this section.

1.2 SUMMARY:

A. Furnish two sets of bound operation and maintenance manuals. Manuals shall contain descriptive drawings and data which identify equipment installed at the project and detail the procedures and parts required to maintain and repair the equipment. Copies of approved submittals shall be included for all equipment.

1.3 OPERATION AND MAINTENANCE MANUAL FOR MECHANICAL SYSTEMS:

A. General:

1. The "Operating and Maintenance Manual" is a bound compilation of drawings and data that the owner requires for each building or project. These manuals, complete with drawings and data, shall be furnished to the Owner.

2. The mechanical contractor has overall responsibility to obtain the necessary data and compile the data as set forth in this specification, including items or equipment purchased by the Owner and delivered to the contractor for installation.

3. The number of binders (or "volumes") required will depend on the amount of information to be catalogued. Total "sets" see paragraph 1.2A.

4. Make all information legible and sufficiently marked to indicate the exact size, model, type, etc., of equipment furnished and installed.

B. Purpose: The Operating and Maintenance Manual is prepared to provide a ready reference to all important pieces of mechanical and electrical equipment installed on the project. It is also to provide the necessary operating and maintenance data for use by service personnel. It is also to provide information required for checking equipment performance or for planning of plant expansion or redesign.

PART II - MATERIALS AND METHODS

2.1 PAGE SIZE: All pages shall be standard 8-1/2 x 11 inches size or approximate multiples (preferably 16 x 11 inches) folded to 8-1/2 x 11 inch.

2.2 DRAWINGS: All drawings larger than 8-1/2" x 11" shall be folded and inserted in individual 8-1/2" x 11" manilla pockets, which shall have standard three-ring side punching for insertion in the binders. The equipment name, drawing description and number shall be written on the face of each manilla pocket.

2.3 BINDERS: Binders shall be Buckram (stiffened fabric), bar-lock type binders with block lettering for sheet size 8-1/2 x 11 inches with 2" to 3-1/2" expandable metal capacity as required for the project. The number of binders, however, shall be based on not filling them beyond 4".

A. Place the following information on the front cover and backbone:

1. "Operation and Maintenance Manual".

2. Project Name (and volume number if more than one volume).

3. Project Number.

4. Building name and number.

5. “Camp Williams”.

6. Architect's name.

7. Engineer's name.

8. General Contractor's name.

9. Mechanical Contractor's name.

10. Items 6 through 8 need not be printed on the backbone.

2.4 CONTENTS AND INDEXING:

A. Manuals shall contain descriptions of the building systems in sufficient detail to adequately indicate the type of systems installed and the basic details of their operation.

B. All purchased equipment data shall be used to designate the sections. Within each section additional indexing of component parts may be required.

C. Operation and Maintenance Manuals shall contain to the fullest extent all possible information pertinent to the equipment. The arrangement and type of information to be filed shall be as follows:

1. Copy of purchase order change (if any).

2. Outline drawings, special construction details, “as built” electrical wiring and control diagrams for all major and supplementary systems.

3. Manufacturer’s test or calculated performance data and certified test curves.

4. Installation, operating, and maintenance instructions, including a complete parts list and sectional drawing with parts identification numbers. Mark with model, size and plan number.

5. Manufacturer’s brochure marked to indicate exact equipment purchased. Brochures on component parts supplied by a manufacturer with his equipment, but not manufactured directly by him, shall also be included.

6. The serial numbers of each item of equipment installed are to be listed with the model numbers and plan symbols.

7. Include a Table of Contents. The contents shall be divided with tabbed index dividers into the following suggested parts:

   a. Part I Building and System Descriptions
   b. Part II Purchased Equipment Data
   c. Part III Test Reports and Valve Charts
   d. Part IV Start-Up and Operation
   e. Part V Preventative Maintenance Recommendations

8. A copy of the approved submittals for each piece of equipment.

9. A copy of all testing, adjusting and balancing reports.

10. Wiring diagrams, marked with model and size and plan symbol.

11. The index shall contain the name and address of the manufacturer and, if different, where replacement and repair parts may be obtained.

PART III – EXECUTION

3.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230100

SECTION 230505 - MECHANICAL FIRESTOPPING

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Related Documents: Drawings and general provisions of the Contract, including General and Supplementary Conditions and General Conditions Specification Sections, apply to this section.

1.2 SUMMARY: This section includes firestopping for the following:

A. Penetrations through fire-resistance-rated floor construction including openings containing wires/cables, pipes, ducts, conduits, and other penetrating items.

B. Penetrations through fire-resistance-rated walls and partitions including openings containing wires/cables, pipes, ducts, control conduits, and other penetrating items.

1.3 SYSTEM PERFORMANCE REQUIREMENTS:

A. General: Provide firestopping systems that are produced and installed to resist the spread of fire, according to requirements indicated, and the passage of smoke and other gases.

B. F-Rated Through-Penetration Firestop Systems: Provide through-penetration firestop systems with F ratings indicated, as determined per ASTM E 814, but not less than that equaling or exceeding the fire-resistance rating of the constructions penetrated.

C. T-Rated Through-Penetration Firestop Systems: Provide through-penetration firestop systems with T ratings, in addition to F ratings, as determined per ASTM E 814, where indicated and where systems protect penetrating items exposed to contact with adjacent materials in occupiable floor areas. T-rated assemblies are required where the following conditions exist:

1. Where firestop systems protect penetrations located outside of wall cavities.

2. Where firestop systems protect penetrations located outside fire-resistive shaft enclosures.

3. Where firestop systems protect penetrating items larger than a 4-inch diameter nominal pipe or 16 square inch in overall cross-sectional area.

D. Fire-Resistive Joint Sealants: Provide joint sealants with fire-resistance ratings indicated, as determined per ASTM E 119, but not less than that equaling or exceeding the fire-resistance rating of the construction in which the joint occurs.

E. For firestopping exposed to view, traffic, moisture, and physical damage, provide products that do not deteriorate when exposed to these conditions.

1. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.

2. For floor penetrations with annular spaces exceeding 4 inches or more in width and exposed to possible loading and traffic.

1.4 SUBMITTALS:

A. General: Submit the following according to Conditions of Contract and General Conditions Specification Sections.

B. Product data for each type of product specified.

1. Certification by firestopping manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs) and are nontoxic to building occupants.

C. Product certificates signed by manufacturers of firestopping products certifying that their products comply with specified requirements.

D. Product test reports from, and based on tests performed by, a qualified testing and inspecting agency evidencing compliance of firestopping with requirements based on comprehensive testing of current products.

1.5 QUALITY ASSURANCE:

A. Fire-Test-Response Characteristics: Provide firestopping that complies with the following requirements and those specified under the "System Performance Requirements" article:

1. Firestopping tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL, Warnock Hersey, or another agency performing testing and follow-up inspection services for firestop systems that is acceptable to authorities having jurisdiction.

2. Through-penetration firestop systems are identical to those tested per ASTM E 814 under conditions where positive furnace pressure differential of at least 0.01 inch of water is maintained at a distance of 0.78 inch below the fill materials surrounding the penetrating items in the test assembly. Provide rated systems complying with the following requirements.

a. Through-penetration firestop system products bear classification marking of qualified testing and inspecting agency.

b. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by UL in their "Fire Resistance Directory," by Warnock Hersey, or by another qualified testing and inspecting agency.

B. Information on drawings referring to specific design designations of through-penetration firestop systems is intended to establish requirements for performance based on conditions that are expected to exist during installation. Any changes in conditions and designated systems require the Architect's prior approval. Submit documentation showing that the performance of proposed substitutions equals or exceeds that of the systems they would replace and are acceptable to authorities having jurisdiction.

C. Installer Qualifications: Engage an experience installer who has completed firestopping that is similar in material, design, and extent to that indicated for the project and that has performed successfully.

D. Single-Source Responsibility: Obtain through-penetration firestop systems for each kind of penetration and construction condition indicated from a single manufacturer.

E. Provide firestopping products containing no detectable asbestos as determined by the method specified in 40 CFR Part 763, Subpart F, Appendix A, Section 1, "Polarized Light Microscopy."

F. Coordinating Work: Coordinate construction of openings and penetrating items to ensure that designated through-penetration firestop systems are installed per specified requirements.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Deliver firestopping products to project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to project; curing time; and mixing instructions for multi-component materials.

B. Store and handle firestopping materials to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.7 PROJECT CONDITIONS:

A. Environmental Conditions: Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilation: Ventilate firestopping per firestopping manufacturer's instructions by natural means or, where this is inadequate, forced air circulation.

1.8 FIRESTOPPING - GENERAL:

A. Compatibility: Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by firestopping manufacturer based on testing and field experience.

B. Accessories: Provide components for each firestopping system that are needed to install fill materials and to comply with "System Performance Requirements" article in Part 1. Use only components specified by the firestopping manufacturer and approved by the qualified testing and inspecting agency for the designated fire-resistance-rated systems. Accessories include but are not limited to the following items:

1. Permanent forming/damming/backing materials including the following:

a. Semi-refractory fiber (mineral wool) insulation.

b. Ceramic fiber.

c. Sealants used in combination with other forming/damming materials to prevent leakage of fill materials in liquid state.

d. Fire-rated formboard.

e. Joint fillers for joint sealants.

2. Temporary forming materials.

3. Substrate primers.

4. Collars.

5. Steel sleeves.

C. Applications: Provide firestopping systems composed of materials specified in this section that comply with system performance and other requirements.

1.9 FILL MATERIALS FOR THROUGH-PENETRATION FIRESTOP SYSTEMS:

A. Intumescent, Latex Sealant: Single-component, intumescent, latex formulation.

B. Intumescent Putty: Non-hardening, dielectric, water-resistant putty containing no solvents, inorganic fibers, or silicone compounds.

C. Intumescent Wrap Strips: Single-component, elastomeric sheet with aluminum foil on one side.

D. Solvent-Release-Curing Intumescent Sealant: Solvent-release-curing, single-component, synthetic-polymer-based sealant.

E. Intumescent Metal-Faced Sheets: Single-component, intumescent sheet with 28-gauge steel bonded to one side.

F. Products: Subject to compliance with requirements, provide one of the following:

1. Intumescent Latex Sealant:

a. Fire Barrier CP 25WB Caulk, 3M Fire Protection Products.

2. Intumescent Putty:

a. Fire Barrier Moldable Putty, 3M Fire Protection Products.

3. Intumescent Wrap Strips:

a. Fire Barrier FS-195 Wrap/Strip, 3M Fire Protection Products.

4. Solvent-Release-Curing Intumescent Sealants:

a. Fire Barrier CP 25N/S Caulk, 3M Fire Protection Products.
b. Fire Barrier CP 25S/L Caulk, 3M Fire Protection Products.

5. Intumescent Metal-Faced Sheets:

a. 3M Fire Barrier Composite Sheet CS195, 3M Fire Protection Products.

1.10 EXAMINATION:

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping. Do not proceed with installation until unsatisfactory conditions have been corrected.

1.11 PREPARATION:

A. Surface Cleaning: Clean out openings and joints immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer and the following requirements:

1. Remove all foreign materials from surfaces of opening and joint substrates and from penetrating items that could interfere with adhesion of firestopping.

2. Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.

B. Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

1.12 INSTALLING THROUGH-PENETRATION FIRESTOPS:

A. General: Comply with the "System Performance Requirements" article in Part 1 and the through-penetration firestop manufacturer's installation instructions and drawings pertaining to products and applications indicated.

B. Install forming/damming materials and other accessories of types required to support fill materials during their application and in the position needed to produce the cross-sectional shapes and depths required to achieve fire ratings of designated through-penetration firestop systems. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:

1. Completely fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.

2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.

1.13 CLEANING:

A. Clean off excess fill materials and sealants adjacent to openings and joints as work progresses by methods and with cleaning materials approved by manufacturers of firestopping products and of products in which opening and joints occur.

B. Protect firestopping during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so that they are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.

PART II – EXECUTION

2.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230505

SECTION 230513 - MOTORS, DRIVES AND ELECTRICAL REQUIREMENTS FOR MECHANICAL WORK

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Related Sections: Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.2 SUMMARY:

A. This section specifies the basic requirements for motors and drives furnished by this Division and for electrical components which are an integral part of packaged mechanical equipment. Package components include, but are not limited to factory installed motors, starters, and disconnect switches, etc.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are noted within these documents.

1.3 QUALITY ASSURANCE:

A. Provide electrical components and materials which are UL labeled.

B. Provide variable speed drives which conform to the latest standard of the following:

1. IEEE - Institute of Electrical and Electronic Engineers.

2. NEC - National Electrical Code.

3. NEMA - National Electrical Manufacturers Association.

4. Provide complete packaged unit(s) which are listed and carry the label of at least one of the following:

   a. UL - Underwriters Laboratory
   b. ETL - ETL Testing Laboratories, Inc.
   c. CSA - Canadian Standards Association

1.4 SUBMITTALS:

A. Submit complete product and application information for variable speed drives as follows:

1. Provide multiple sets of drawings of system (VFD) being supplied, in strict compliance with the specifications. Include, as a minimum:

   a. General arrangement of each unit showing size and incoming and outgoing conduit locations.

   b. Schematic.

   c. Connection diagram, sufficient to install drive system.

2. Provide each unit with four owner/maintenance manuals which shall include:

a. Vendor information of equipment being supplied.

b. Connection information.

c. Start up procedure.

d. Fault reset instruction.

e. Wiring diagrams (power and control).

f. Parts list.

g. Test results.

h. Harmonic voltage distortion on line with unit off.

i. Harmonic voltage distortion with unit on line.

B. Submit product data for motors, belts, drives, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification sections. Verify project electrical characteristics with submittal. Confirm suitability for altitude, maintaining full nameplate rating plus service factor. Include this data in maintenance manual in accordance with Section "Operation and Maintenance Manuals".

1.5 REFERENCES:

A. NEMA Standards MG 1: Motors and Generators.

B. NEMA Standards ICS 2: Industrial Control Devices, Controllers, and Assemblies.

C. NEMA Standards 250: Enclosures for Electrical Equipment.

D. NEMA Standards KS 1: Enclosed Switches.

E. Comply with National Electrical Code (NFPA 70).

1.6 WARRANTY:

A. General: For variable frequency drives. Furnish a written warranty consisting of the following:

1. Warranty parts and labor for five years after substantial completion.

PART II - PRODUCTS

2.1 MOTORS:

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.

2. Motor sizes large enough so that the driven load will not require the motor to operate in the service factor range.

3. Two-speed motors with 2 separate windings for poly-phase motors. Confirm 2-speed starter requirements with Division 26.

4. Single speed motors of the permanent split capacitor type. (PSC)

5. Temperature Rating: Minimum rate for 40^{o}C environment with maximum 90^{o}C temperature rise for continuous duty at full load (Class H Insulation for altitude, Class B leads allowed).

6. Starting Capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly timed spaced starts per hour for manually controlled motors.

7. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors, 1.0 for TEFC motors.

8. Pump motors with an end shield with ventilation openings beneath the motor.

9. Motor Construction: NEMA Standard MG 1, general Purpose, continuous duty, design "B", except "C" where required for high starting torque.

10. Frames: NEMA Standard No. 48 or 54; T-frame, use driven equipment manufacturer's standards to suit specific application.

11. Bearings:

    a. Ball or roller bearings with inner and outer shaft seals;

    b. Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance;

    c. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor;

    d. For fractional horsepower, light duty motors, sleeve type bearings are permitted;

12. Enclosure Type:

    a. Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation;
    b. Guarded drip-proof motors where exposed to contact by employees or building occupants;

    c. Weather protected type I for outdoor use, Type II where not housed;

13. Overload Protection: built-in thermal overload protection and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.

14. Noise Rating: "Quiet"

15. Efficiency: "Premium Energy Efficient" motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, test method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112. Motors used with Variable Frequency Drives shall be compatible and designed for use with Variable Frequency Drives. Any “explosion proof” motor for classified areas, scheduled for use with VFD’s, shall be listed for invertor duty applications.

16. Nameplate: indicate the full identification of manufacturer. ratings, characteristics, construction, special features and similar information.

17. Acceptable Manufacturers: Allis-Chalmers, Baldor, Century, General Electric, Gould, Lincoln, Louis-Allis, Marathon, Reliance, U.S. Motors, Westinghouse.

2.2 MOTOR DRIVES:

A. Provide fan/motor drives with cast steel sheaves and V-belt sets of fabric and rubber construction by Browning, Dodge, Woods. Match multiple belts and adjust to drive the apparatus properly and to prevent slippage and undue wear in starting. Design drives for 150 percent or more of the specified motor nameplate rating. Bush all drives. Belts shall be A, B or C section belts. Narrow gauge belts are not acceptable. Adjust drives or replace sheaves as needed to obtain required capacities.

B. Provide flexible coupled drives for pumps by Browning, Dodge or Woods.

C. Provide a galvanized iron metal guard for each V-belt drive, coupled drive or rotating shaft constructed around an angle iron frame, securely bolted to the floor or apparatus. Design the guard to completely enclose drives and pulleys and be constructed to comply with all safety requirements. Provide hinged access doors not less than 6" x 6" for access to motor and fan shaft for test purposes. For double inlet fans, construct the belt guard cover of 1/2" mesh expanded metal, arranged as not to restrict the air flow into the fan inlet.

PART III – EXECUTION

3.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230513

SECTION 230519 - THERMOMETERS AND PRESSURE GAUGES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. This section is Division 23 Thermometers and Pressure Gauges section, and is part of each Division 23 section making reference to thermometers and pressure gauges specified herein.

C. Division 23 General Mechanical Requirements apply to work of this section.

1.2 SUMMARY

A. Meters and gauges specified in this section include the following:

1. Temperature Gauges and Fittings.

    a. Digital Thermometers.
    b. Thermometer Wells.
    c. Temperature Gauge Connector Plugs.

2. Pressure Gauges and Fittings.

    a. Pressure Gauges.
    b. Pressure Gauge Valves.
    c. Pressure Gauge Connector Plugs.

1.3 QUALITY ASSURANCE:

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of thermometers and/or pressure gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Temperature and Pressure Gauge Types: Provide temperature and pressure gauges of same type by same manufacturer.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of thermometer and pressure gauge.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of thermometer and pressure gauge. Include this data, product data, and shop drawings in Maintenance Manual; in accordance with requirements of General Conditions.

PART II - PRODUCTS

2.1 DIGITAL THERMOMETERS:

A. General: Provide digital thermometers, designed and constructed for use in service indicated variable angle, light powered.

B. Case: High impact ABS.

C. Range: -40/300°F.

D. Display: 3/8" LLD digits.

E. Accuracy: 1% of reading or 1°F, whichever is greater.

F. Resolution: 1/10° between -19.9°/199.9°F.

G. Recalibration: Internal potentiometer.

H. Lux Rating: 10 lux.

I. Update: 10 seconds.

J. Ambient Operating: -30/110°F.

K. Sensor: Glass passivated thermistor.

L. Stem Assembly: Industrial Glass.

M. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:

1. Weiss Instruments, Inc.
2. Weksler

2.2 THERMOMETER WELLS:

A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

B. Manufacturer: Same as thermometers.

2.3 TEMPERATURE/PRESSURE GAUGE CONNECTOR PLUGS:

A. General: Provide temperature gauge connector plugs pressure rated for 500 psi and 200 degrees F (93 degrees C). Construct of brass and finish in nickel-plate, equip with ½" NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

B. Manufacturer: Subject to compliance with requirements, provide temperature gauge connector plugs of one of the following:

1. Peterson Equipment Co.

2. SISCO
3. Universal
4. Flow Design

2.4 PRESSURE GAUGE VALVES:

A. General: Provide pressure gauge valves between pressure gauges and gauge tees on piping systems. Use 1/4" ball valve with tee handle.

PART III – EXECUTION

3.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230519

SECTION 230523 - VALVES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. This section is Division 23 Valves section, and is part of each Division 23 section making reference to valves specified herein.

C. Division 23 General Mechanical Requirements apply to work of this section.

1.2 SUMMARY:

A. Extent of valves required by this section is indicated on drawings and/or specified in other Division 23 sections.

B. Types of valves specified in section include the following:

1. Drain Valves.
2. Ball Valves.
3. Plug Valves.
4. Butterfly Valves.
5. Check Valves.
6. Swing Check.
7. Miscellaneous Valves.

C. Valves furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.

1.3 QUALITY ASSURANCE:

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of valves, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Valve Types: Provide valves of same type by same manufacturer.

C. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on valve body.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing Manufacturer's figure number, size, location, and valve features for each required valve.

B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes and Standards:

1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".

2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".

3. UL and FM Compliance: Provide valves used in fire protection piping, which are UL-listed and FM approved.

PART II - PRODUCTS

2.1 VALVES:

A. General: Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

B. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size.

C. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 4" and smaller, other than plug valves. Provide one wrench for every 10 plug valves. Provide gear operators for quarter-turn valves 6" and larger. Provide chain-operated sheaves and chains for overhead valves 8'-0" and higher above finished floor.

D. Connections: Unless otherwise noted for a particular reason, any valve 2" and larger shall have flanges. For grooved joint steel pipe in 6" and larger sizes, convert to flanged pipe, use indicated ball or butterfly valves.

2.2 HOT WATER HEATING AND CHILLED WATER:

A. Ball Valves:

1. Steel piping, 2” and smaller: 400 psig WOG @ 250ºF, bronze construction, threaded ends, bubble tight mineral filled PTFE seat at 250 psig under water, hard, stainless steel ball and stem. Operate with flow in either direction. Lever or tee handle as required. Suitable for throttling and tight shut-off. Watts B-6000-SS or B-6001-SS, Apollo 70-100 or 70-200, Millwaukee BA-100S or BA 150S, Hammond, Belimo. No other manufacturers approved. All drain valves shall be furnished with capped 3/4” threaded hose outlet connection.

2. Copper piping, 2” and smaller: 400 psig WOG @ 250ºF bronze construction, threaded or solder ends, bubble tight mineral filled. PTFE seat at 250 psig under water, hard stainless steel ball and stem. Operate with flow in either direction. Lever or tee handle as required. Suitable for tight shut-off. Watts B-6000-SS or B-6001-SS, Apollo 70-100 or 70-200, Milwaukee BA-100S or BA-150S, Hammond, Belimo. No other manufacturer approved. All drain valves shall be furnished with capped 3/4” threaded hose outlet connection.

B. Butterfly Valves:

For piping 2-1/2" and larger. Install with weld neck flanges, Norris Series R-3011-23SS-2B, double tapped lug, single-flange ductile iron or cast iron body, 316 SS disc, stainless steel shaft with extended neck for insulated pipe, EPDM seat and O-rings, indicating worm gear operator, 175 psig bubble tight pressure rating (250 where required). Demco, Keystone, Rockwell, Grinnell, Bray, ABZ or Milwaukee.

C. Swing Check Valves:

1. 2" and Smaller: Crane No. 37 bronze, threaded, Y-pattern, 200# WOG at swing check valve.

2. 2-1/2" and Larger: Crane No. 373, iron body, flanged, 200# WOG swing check valve with bronze trim.

D. Non-Slam Check Valves for Pump Discharge:

1. 2" and Smaller: 125 psig WSP, silent, spring loaded, all stainless steel. Durabla or approved equal by valve and Primer Corporation.

2. 2-1/2" and Larger: 125 psig WSP, silent, semi-steel body, bronze trim and discs, bronze seats with center guide and renewable with reseating with special tools, guided spring. Spring shall operate in horizontal, vertical, angular, or upside down position. Approved manufacturers: Nibco/Scott, Smolensky, Clow 363, Miller, Bell and Gosset, Mueller and Armstrong NWS.

E. Balancing Cocks:

1. 2" and Smaller: 175 psig WOG, cast iron body, square head, screwed ends, wrench operated, lubricated.

2. 2-1/2" and Larger: 200 psig WOG, cast iron body, square head, flanged ends, wrench operated, lubricated.

F. Balancing Valves: Circuit balancing valve with venturi and pressure taps. Do not use gate valves or butterfly valves as balancing valves. Provide schedule showing pressure drop and flow rate of each valve. Flow Set Accusetter, Gerund, Armstrong. If improperly sized balance valves are found during the test and balance work, the improperly sized balanced valves shall be replaced by the contractor at no additional cost to the Owner or project.

2.3 DOMESTIC COLD WATER, DOMESTIC HOT WATER, AND DOMESTIC HOT WATER RETURN (COPPER PIPE):

A. BALL VALVES: For valves 2” and smaller, same as in 2.2.A.2. sweat or threaded ends.

B. BALL VALVES: For piping larger than 2”, Victaulic Series 726 Vic-Ball valve. Ductile iron body, chrome plated carbon steel stem, 316 stainless steel ball, TFE Seat, lever handle for size up to 4” gear operator for valves over 6”.

C. SWING CHECK VALVES: Same as in 2.02.C.

2.4 MISCELLANEOUS VALVES AND SPECIALTIES:

A. Air Vent Valves: Stockham B-64, 300 psi working pressure, 3/8" bronze or Crane No. 88.

B. Water Pressure Reducing Valves: For making up to heating systems, Watts No. 223, capacity as required. Bell and Gossett, Conbraco, Watson McDaniel.

C. Water Pressure Relief Valves: For relief for heating system and chilled water system, Watts Series 40/140/240/340 rated for duty, pressure setting as required. Bell and Gossett, Conbraco, Watson McDaniel.

D. Gauge Valves: Ball valve with Tee handle.

E. Valve should be installed with bonnets at least 45 degrees above the horizontal to ensure debris does not collect in bonnet.

PART III - INSTALLATION

3.1 VALVE INSTALLATION:

A. Locate all valves in locations which will allow easy operation and facilitate maintenance.

B. Install valves with stems horizontal or above.

C. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

D. All branch lines which supply a specific area of the building (such as a toilet room) shall be valved near the main so that each area may be isolated from the system for repairs without having to shut down both men and women's restrooms, other areas, or the whole building.

E. Make all valves located above a non-lay-in type ceiling or behind a wall accessible by means of an access door.

PART IV – EXECUTION

4.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230523

SECTION 230529 - MECHANICAL SUPPORTING DEVICES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. This section is Division 23 Mechanical Supporting Devices section, and is part of each Division 23 section making reference to supports and anchors specified herein.

C. Division 23 General Mechanical Requirements apply to work of this section.

1.2 SUMMARY:

A. Extent of supports and anchors required by this section is indicated on drawings and/or specified in other Division 23 sections.

B. Types of supports and anchors specified in this section include the following:

1. Horizontal-Piping Hangers and Supports.
2. Vertical-Piping Clamps.
3. Hanger-Rod Attachments.
4. Building Attachments and In-Beds.
5. Saddles and Shields.
6. Miscellaneous Materials.
7. Roof Equipment Supports.
8. Anchors.
9. Equipment Supports.

C. Supports and anchors furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.

D. Relate this section to Section 23 05 48 regarding seismic and vibration control.

1.3 QUALITY ASSURANCE:

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor.

B. Shop Drawings:

1. Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes and Standards:

1. Code Compliance: Comply with applicable building, mechanical and plumbing codes pertaining to product materials and installation of supports and anchors.

2. UL and FM Compliance: Provide products which are UL-listed and FM approved.

3. MSS Standard Compliance:

a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.

b. Select and apply pipe hangers and supports, complying with MSS SP-69.

c. Fabricate and install pipe hangers and supports, complying with MSS SP-89.

d. Terminology used in this section is defined in MSS SP-90.

PART II - PRODUCTS

2.1 HORIZONTAL-PIPING HANGERS AND SUPPORTS:

A. General: Except as otherwise indicated, provide factory- fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.

B. Adjustable Steel Clevises Hangers: MSS Type 1. (For suspension of non-insulated or insulated stationary pipe lines; 1/2" to 30".)

C. Steel Double Bolt Pipe Clamps: MSS Type 3. (For suspension of pipe requiring up to 4" of insulation and where flexibility of clamp is desirable; 3/4" to 24".)

D. Steel Pipe Clamps: MSS Type 4. (For suspension of cold pipe lines or hot lines where little or no insulation is required; 1/2" to 24".)

E. Pipe Hangers: MSS Type 5. (For suspension of piping when off-center closure allowing installation of hanger before erection of piping is desired; 1/2" to 4".)

F. Adjustable Swivel Pipe Rings: MSS Type 6. (For suspension of non-insulated stationary pipe lines; 3/4" to 8".)

G. Adjustable Steel Band Hangers: MSS Type 7. (For suspension of non-insulated stationary pipe lines; 3/4" to 8".)

H. Adjustable Band Hangers: MSS Type 9. (For suspension of non-insulated stationary pipe liens; 1/2" to 8".)

I. Adjustable Swivel Rings, Band Type: MSS Type 10. (For suspension of non-insulated stationary pipe lines; 3/8" to 8".)

J. Split Pipe Rings: MSS Type 11. (For suspension of non-insulated stationary pipe lines; 3/8" to 3".)

K. Extension Split Pipe Clamps: MSS Type 12. (For suspension of non-insulated stationary pipe lines; 3/8" to 3".)

L. U-Bolts: MSS Type 24. (For support of heavy loads; 1/2" to 30".)

M. Clips: MSS Type 26. (For support of uninsulated piping not subject to expansion or contraction.)

N. Pipe Saddle Supports: MSS Type 36, including steel pipe base- support and cast-iron floor flange. (To support pipe from floor stanchion, using floor flange to secure stanchion to floor 4" to 36".)

O. Pipe Stanchion Saddles: MSS Type 37, including steel pipe base support and cast-iron floor flange. (To Type 36 except U-bolt provided for retaining pipe.)

2.2 VERTICAL-PIPING CLAMPS:

A. General: Except as otherwise indicated, provide factory- fabricated vertical-piping clamps complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.

B. Two-Bolt Riser Clamps: MSS Type 8. (For support and steadying of pipe risers; 3/4" to 20". Also supports pipe covering or insulation.)

C. Four-Bolt Riser Clamps: MSS Type 42. (When longer ends are required for riser clamps.)

2.3 HANGER-ROD ATTACHMENTS:

A. General: Except as otherwise indicated, provide factory- fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.

B. Steel Turnbuckles: MSS Type 13. (For adjustment up to 6" for heavy loads.)

C. Steel Clevises: MSS Type 14. (For use on high temperature piping installations.)

D. Swivel Turnbuckles: MSS Type 15. (For use with split pipe rings, MSS type 11.)

E. Malleable Iron Sockets: MSS Type 16. (For attaching hanger rod to various types of building attachments.)

2.4 BUILDING ATTACHMENTS AND IN-BEDS:

A. General: Except as otherwise indicated, provide factory- fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.

B. Concrete Inserts: MSS Type 18. (For upper attachment for suspending pipe hangers from concrete ceiling.)

C. Top Beam C-Clamp: MSS Type 19. (Use under roof installations with bar joist construction, for attachment to top flange of structural shape.)

D. Side Beam or Channel Clamps: MSS Type 20. (For attachment to bottom flange of beams, channels, or angles.)

E. Center Beam Clamps: MSS Type 21. (For attachment to center of bottom flange of beams.)

F. Welded Beam Attachments: MSS Type 22. (For attachment to bottom of beams where loads are considerable and rod sizes are large.)

G. C-Clamps: MS Type 23. (For attachment to structural shapes.)

H. Top Beam Clamps: MSS Type 25. (For attachment to top of beams when hanger rod is required tangent to edge of flange.)

I. Side Beam Clamps: MSS Type 27. (For attachment to bottom of steel I-beams.)

J. Steel Beam Clamps with Eye Nut: MSS Type 28. (Same as Type 28 with link extensions.)

K. Linked Steel Clamps with Eye Nut: MSS Type 29. (Same as Type 28 with link extensions.)

L. Malleable Beam Clamps: MSS Type 30. (For attachment to structural steel.)

M. Steel Brackets: One of the following for indicated loading:

1. Light Duty: MSS Type 31, to 570 pounds.

2. Medium Duty: MSS Type 32, to 1,500 pounds.

3. Heavy Duty: MSS Type 33, to 3,000 pounds.

N. Side Beam Brackets: MSS Type 34. (For use on sides of steel or wooden beams.)

O. Plate Lugs: MSS Type 57. (For attachment to steel beams where flexibility at the beam is desired.)

P. Horizontal Travelers: MSS Type 58. (For supporting piping systems subject to linear horizontal movements where head room is limited.

Q. Refer to drawings for Unistrut inserts.

2.5 SADDLES AND SHIELDS:

A. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

B. Protection Saddles: MSS Type 39; see section Mechanical Insulation for void fill requirements. Use for roller supports and on all pipes 10" and larger.

C. Protection Shields: See section Mechanical Insulation.

D. Thermal Hanger Shields: See section Mechanical Insulation.

E. Manufacturer; Subject to compliance with requirements, provide thermal hanger shields of one of the following:

1. Elcen Metal Products Co.
2. Pipe Shields, Inc.

2.6 MANUFACTURERS OF HANGERS AND SUPPORTS:

A. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:

1. Kin-Line, Inc.
2. Fee & Mason Mfg. Co.; Div. Figgie International
3. ITT Grinnel Corp.
4. B-Line
5. Unistrut

2.7 HIGH HUMIDITY AREAS: Use cadmium plated or galvanized hangers, attachments, rods, nuts, bolts and other accessories in boiler rooms or other high humidity areas.

2.8 OUTSIDE AREAS: Use galvanized hangers, attachments, rods, nuts, bolts and other accessories for all outside areas.

2.9 MISCELLANEOUS MATERIALS:

A. Metal Framing: Provide products complying with NEMA STD ML 1.

B. Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.

C. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration. Use Embeco grout for non-shrink applications.

D. Heavy Duty Steel Trapezes: Fabricate from factory built channel (Unistrut) system and use factory fasteners for channel steel shapes, selected for loads required; weld steel in accordance with AWS standards.

E. Pipe Guides: Provide factory-fabricated guides, of cast semi- steel or heavy fabricated steel, consisting of bolted two- section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION:

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:

A. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms.

1. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through the openings at the tops of inserts.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:

A. General: Install hangers, supports, clamps and attachments to rigidly support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

C. Prevent electrolysis in support of copper tubing by the use of hangers and supports which are copper plated, or by isolating with foam rubber covering or 30 mil insulating tape.

D. Provisions for Movement:

1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

2. Install supports within 2 feet of non-vertical flex connectors.

E. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.

G. Insulated Piping: Do not allow hangers to come in contact with pipe where pipe is specified to be insulated.

H. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

I. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold or chilled water piping, install galvanized steel protective shields. Install calcium silicate blocks (12" long minimum) at support points.

J. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

3.5 INSTALLATION OF ANCHORS:

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer for loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.6 EQUIPMENT SUPPORTS:

A. Provide concrete housekeeping bases for all floor mounted equipment furnished as part of the work of Division 15. Size bases to extend a minimum of 4" beyond equipment base in any direction; and 4" above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.

B. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

3.7 ADJUSTING AND CLEANING:

A. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.

B. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.

C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.8 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230529

SECTION 230548 - MECHANICAL SOUND, VIBRATION AND SEISMIC CONTROL

PART I - GENERAL:

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. This section is Division 23 Mechanical Sound, Vibration and Seismic Control section, and is part of each Division 23 section making reference to mechanical sound, vibration and seismic control specified herein.

C. Division 23 General Mechanical Requirements apply to work of this section.

1.2 SUMMARY: Furnish and install complete seismic restraint and vibration control systems for all work installed under Division 23. Including owner furnished contractor installed equipment. Work to be responsive to the intent of the International Building Code, latest adopted edition, for the respective seismic zone. Zone 3, importance factor of 1.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Engage the services of an independent seismic and vibration control subcontractor who has the technology, experience, computer capabilities and manufactured products to prepare the required computations, shop drawings and special devices to meet the minimum requirements described herein. Select from the following:

1. Amber Booth
2. Kinetics
3. Mason

B. The seismic and vibration control subcontractor shall visit the site during construction at a minimum of two specific periods.

1. When equipment is set in place, prior to placement of seismic restraint devices for the purposes of directing the contractor in properly locating and installing the approved devices.

2. At the completion of the project, prior to final mechanical inspection, for the purpose of verifying the correctness of the seismic restraint and vibration isolation device installation and preparing certification of the seismic vibration-isolation work.

C. The seismic subcontractor shall exercise the quality control for this work and shall include, but not be limited to instructions direct to the Mechanical (Division 23) Contractor concerning:

1. Anchoring of all mechanical equipment including owner furnished and contractor installed.

2. Vibration mounting of equipment.

3. Equipment base coordination with restraint requirements.

4. Snubbing of equipment.

5. Bracing and anchoring of ductwork piping and conduit.

6. Provision for expansion and vibration of piping.

7. Concrete and/or steel pads or bases to assure proper mounting of restraints and isolators.

8. Vibration isolation of exhaust fans, relief fans, ventilation fans, and supply air fans.

D. The subcontractor shall be responsible for identifying the need for the size and location of steel sole plates and their attachment to structural steel or concrete.

E. The subcontractor shall certify in writing that he has inspected the installation and that all isolation, anchors and seismic restraint materials are installed correctly and functioning properly. Certification shall be provided after all corrective work has been completed.

1.4 SUBMITTALS:

A. Submittal data is required and shall consist of computations, vibration isolation selection, equipment anchors, anchor bolt sizes, supports, seismic restraints, sole plate data, restraint locations and type of restraints.

B. Submittal data shall identify dimensions, load deflection data, center of gravity, standard connections, manufacturer's recommendations, behavior problems including vibrations, thermal expansion, building expansion joints, etc., associated with equipment, ductwork, piping and conduit.

C. Calculations need not be submitted when restraint devices for piping, conduit and ductwork are proposed in accordance with the SMACNA Guidelines for Seismic Restraints.

D. Selection of isolator anchors and restraints shall be clearly made known along with the basis for selection so that proposed systems can be reviewed.

E. Calculations furnished for anchors, anchor bolts, sole plates and other support steel for restraining devices shall be signed and stamped by an engineer licensed in one of the United States.

1.5 REFERENCES:

A. Codes and Standards: (Latest adopted edition)

1. International Building Code
2. NFPA bulletin 90A,
3. UL Standard 181
4. Guidelines for seismic restraint of Mechanical Systems and Plumbing Piping Systems. Published by the Sheet Metal Industry Fund of Los Angeles, California, and the Plumbing and Piping Industry Council, Inc., Los Angeles, California.

PART II - PRODUCTS:

2.1 MATERIALS - PRODUCTS: Restraint devices shall be especially designed to resist seismic forces in all directions.

A. Snubbers: Restraint surfaces which engage under seismic motion shall be cushioned with a resilient elastomer neoprene (bridge bearing neoprene) to protect equipment. Restraints shall allow a maximum of 1/4" before engaging and shall not interfere in normal starting or stopping operation. Housing shall allow for visual inspection to determine clearances during system operation. Restraints shall be field adjustable and be positioned for up to 1/4" clearance both horizontally and vertically. Mountings and snubbers are to be manufactured under a Quality Assurance (QA) Program.

B. Snubbers and Isolator Combination Devices: Combination unitized devices may be used where equipment isolation is required. They shall include the requirements listed for snubbers. Isolation portion shall be stable spring type with combination leveling bolt and equipment fastening device. Base plate shall have adequate means for bolting to structure. The spring assembly shall be removable and shall fit within a welded steel enclosure.

C. Piping, Conduit and Duct Restraints: Restraint materials for exposed installation shall be standard fabricated flat steel, angle rod and channel members.

1. Restraint members shall be bolt connected. Cabling materials and methods shall be used only in chases or concealed ceiling spaces.

PART III - EXECUTION

3.1 SEISMIC RESTRAINT GUIDELINE:

A. Guidelines for SMACNA seismic restraints for conduit, piping and ductwork are to serve as the basis for restraint methods. (Exception - no cabling shall be used in the restraint systems except as noted.)

3.2 SEISMIC RESTRAINT-PIPING AND CONDUIT:

A. General: All piping and conduit shall be protected in all planes by restraints, designed to accommodate thermal movement while at the same time restraining seismic motion. Tanks and vessels connected to piping shall be restrained in the same manner as the piping.

B. Locations of the restraints shall include, but not be limited to:

1. At all drops or risers to equipment connections.

2. At all changes in direction of piping and conduit.

3. At all horizontal runs of pipe and conduit to keep it in alignment and prevent sagging with restraints not to exceed the following:

a. Transverse bracing at 40'-0" O.C. maximum.
b. Longitudinal bracing at 80'-0" O.C. maximum.

4. Provide flexibility in joints where pipes pass through building seismic or expansion joints.

5. On both sides of flexible connectors.

C. Exceptions:

1. Conduit under 2-1/2" size and piping under 1-1/2" size need not be additionally

seismically restrained except as follows:

a. Brace all piping and conduit 1-1/4" and larger in boiler rooms, mechanical rooms, electrical equipment rooms and refrigeration machinery rooms.

b. Brace all fuel gas and oil piping, medical gas piping and compressed air piping 1" and larger.

2. Seismic bracing may be omitted:

a. When the top of the pipe is suspended 12" or less from the supporting structure member and the pipe or conduit is suspended by an individual hanger.

b. On all piping 3/4" and smaller.

3.3 SEISMIC RESTRAINT INSULATED PIPING: Where piping is designated to be insulated, the points of support shall be protected by a 360° sheet metal shield. Insert insulation shall be of the same thickness as the adjoining pipe insulation. (Pipe Shields, Inc.)

The sheet metal shield wrapped around the insert shall be of the following lengths and gauge thickness.

PIPE SIZE	SHIELD LENGTH	MINIMUM GAUGE
1/2 - 1-1/2"	4"	20
2 - 6"	6"	20
8 - 10"	9"	16
12 - 18"	12"	16
20 and up	18"	16

3.4 SEISMIC RESTRAINT - PIPING AT FIRE-WALL AND FLOOR PENETRATION WHERE WALL IS USED AS A RESTRAINT:

A. Bare Pipe: Encase pipe in minimum 24 gauge sheet metal can sized for one inch spacing between pipe and outer diameter of can. Spacing shall be packed in accordance with fire resistant/retardant materials in accordance with Section: FIRE STOPPING.

B. Insulated Pipe: Encase in adjustable or fixed length cans, minimum 24 gauge, sized for maximum one inch spacing between insulation and outer diameter of can. Insulation shall consist of 360° insert sized to extend a minimum of 1" beyond wall or floor penetration and of the same thickness as the adjoining insulation. Spacing between shield and can shall be packed in accordance with Section: FIRE STOPPING.

3.5 SEISMIC RESTRAINT GROOVED PIPING:

A. Where grooved piping is selected as the piping system, it must be seismically restrained as well as provide for thermal movement.

B. Pipes may not be fastened to differently moving structures such as a wall or a ceiling, or a ceiling and a floor. The intent is to have the piping system move with the structure and not separate from it.

C. In general, grooved piping shall be provided with additional flexible couplings to allow extreme deflections to occur, yet restrained to prevent movement beyond the limits of the

flexible connections. Linear movement shall be incorporated as a part of the flexible connections or in a swing joint arrangement.

D. Groove piping systems shall be separated, analyzed and submitted from threaded or welded piping systems.

3.6 SEISMIC RESTRAINT - DUCTWORK:

A. Ductwork, four feet square and larger in cross sectional area or 26" diameter and larger shall be protected in all places by restraints. Locations shall include, but not be limited to:

1. At all equipment connections.

2. At all duct turns and duct run ends (transverse bracing).

3. Transverse bracing to occur 30'-0" O.C. maximum. Rectangular ducts 61" and larger in either direction may be braced at 32'-0" O.C.

4. Longitudinal bracing shall occur at 60'-0" O.C. maximum.

B. A group of ducts may be combined in a larger size frame using the overall dimensions with maximum weight for selection of restraint members.

C. No bracing is required if the top of the duct is suspended 12" or less from supporting member and attached at the top of the duct as well as sides and bottom.

3.7 VIBRATION ISOLATION:

A. General: Furnish and install devices to isolate moving equipment from the structure. Review isolation furnished with factory package equipment, require conformance with project criteria.

B. Basic Criteria: Vibration isolation devices which have natural frequencies approximately 1/10 that of the related driving frequency.

C. Equipment to Include:

1. Supply Air Fans: Vibration isolated and seismic restrained on inertia base. Inertia base shall have 1.5 times total weight of assembly.

2. Suspended inline ventilation fans.

3. Propeller relief air fans and ventilation fans.

4. Roof mounted utility exhaust fans.

D. Field Verify: All required devices and installation.

3.8 VIBRATION ISOLATION - DUCTWORK AND PIPING:

A. Furnish and install devices to isolate all piping and ductwork from other moving equipment. Provide flex connections, spring hangers, grooved joint couplings for pipe, etc., as required.

3.9 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230548

SECTION 230553 - MECHANICAL IDENTIFICATION

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Basic Mechanical Materials and Methods section apply to work of this section.

1.2 SUMMARY:

A. Label all plumbing, heating, air conditioning, automatic temperature control equipment (excluding thermostats and relays), and distribution systems. Also label all electrical switches and starters for all mechanical equipment. Label all fire dampers, fire smoke dampers, smoke damper access doors.

PART II - GENERAL MECHANICAL MATERIALS AND METHODS

2.1 EQUIPMENT, PIPE AND DUCT IDENTIFICATION:

A. Equipment:

1. Use the same identification number and name as that shown on the drawings or in these specifications. Make equipment nameplates of black face formica with white engraved lettering 3/16" high or larger, attached securely.

2. Include the following information on equipment nameplates where applicable:

Identification name.
Identification number.
Capacity specified.
Actual capacity.
Area or zone served.

Note operating conditions, including head or static pressure, RPM, motor horsepower at design conditions, area or zone served, name of lubricant, frequency of lubrication.

B. Valve Identification:

1. For all valves, regardless of size, provide brass tags at least 1-1/4" by 3" in size and 0.051 inches thick. Use engraved lettering at least 1/8" high. Identify each valve on the drawing separately, and with valve tags matching the drawing identification.

2. Provide valve tags which include the following minimum information:

a. Normal Position
b. Duty

3. Identify tag numbers as follows:

Valve Tags	Duty
1-99	HW
100	CHW
200	CW
300	DWC & DWH
400	FIRE
500	AIR
600	DEM W

4. Make a schedule of all tagged valves, include in O & M Manuals.

5. Connect valve tags to valve stems with brass chain.

C. Color code all accessible duct and piping and identify with wording and arrows every 50 feet, at each riser, at each junction, at each access door, and where required to easily identify the medium transported.

D. Identify duct and piping systems by:

1. Lettering color, and

2. Flow Direction Arrow.

3. Identifying lettering shall be painted or stenciled on duct or pipe. Self-adhesive or glue-on type labels are acceptable. Letters shall be 2" high for duct and for 3" or larger piping, 1" high for 1-1/4" to 2-1/2" pipe, and 1/2" high for 1" pipe and smaller.

4. Arrows to indicate direction of flow shall be painted or stenciled on the duct or pipe in the same color as the lettering. The arrow shall point away from the lettering. On duct and 3" or larger piping, the “shaft” of the arrow shall be 2" long and 1" wide. Smaller piping, 2-1/2" or less, shall have arrows with a shaft 1/2" wide and 2" long. Use a double-headed arrow if the flow can be in either direction.

5. Piping and duct shall be identified with the following colors:

6. Label existing high temperature water piping.

Medium in Pipe or Duct	Banding Color	Identifying Lettering	Abbreviation & Lettering Color
Chilled Water Supply	One Blue	Chilled Water Supply	CHWS Black
Chilled Water Return	Two Blue	Chilled Water Return	CHWR Black
Domestic Cold Water	One Green	Domestic Cold Water	DWC Black
Domestic Cold Water	One Green	Domestic Soft Cold Water	DSCW Black
Domestic (Potable) Hot Water	One Yellow Two Green	Domestic Hot Water	DWH Black

Domestic Hot Water Return	One Yellow Two Green	Domestic Hot Water Return	DWHR Black
Fire Protection Water	Red	Fire Protection	Fine Black
Heating Water Supply (Bldg. Heat)	One Yellow Two Orange	Heating Water Supply	BHWS Black
Heating Water Return (Bldg. Heat)	One Yellow One Orange	Heating Water Return	BHWR Black
Roof Drain	Green	Roof Drain	R. D. Black
Control Air	Aluminum	Control Air	C Air Black
Drain		Drain	Black
Building Waste	(Unpainted or Black)	Waste	White

Cold Air Duct	Cold Air Duct (Unit Served) - Black
Hot Air Duct	Hot Air Duct (Unit Served) - Black
Return Air Duct	Return Air Duct (Unit Served) - Black
Exhaust Air Duct	Exhaust Air Duct (Unit Served) - Black
Supply Duct	Supply Duct (Unit Served)

Fire, Smoke, Fire/Smoke Damper — Fire, Smoke, Access Doors Fire/Smoke Damper AD – Red

2.2 PANEL IDENTIFICATION:

A. Provide all panel devices on panel faces with engraved black face formica with white engraved lettering labels.

B. Provide all internal panel components with engraved black face formica labels with white engraved lettering. Fasten label beneath each device.

C. Numerically or alphabetically code all panel wiring and tubing.

PART III – EXECUTION

3.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230553

SECTION 230593 - SYSTEM TESTING AND BALANCING

PART I - GENERAL

1.1 GENERAL CONDITIONS:

A. Work of this section shall be subject to the requirements of the General Conditions of this contract, the General Mechanical Requirements, General Electrical Requirements and other sections where this work shares a responsibility.

B. System commissioning and startup of the mechanical systems shall be the responsibility of the Mechanical Contractor and his subcontractors with the participation of the Electrical Contractor related to electrical work and the General Contractor related to general construction items.

C. Testing and Balancing shall be the responsibility of the Mechanical Contractor under the direction of the General Contractor with the full participation of all of the mechanical and electrical trades employed on the project and shall include the participation of an independent testing and balance contractor to coordinate all elements of the work and to perform special technical services outlined herein.

1.2 SYSTEM START-UP - EXTENT OF WORK:

A. The work required by this section includes but is not necessarily limited to the following:

1. The pre-startup inspection of all systems and subsequent correction of any incorrect items.

2. The initial first run inspections.

3. System operations inspection.

B. The intent of this work is to provide for proper installation, startup, service and operation of the mechanical systems in preparation for system balancing.

C. Repair, replacement or adjustment of each item shall be performed by the installing contractor.

D. Involves all new construction and those elements of existing construction which are affected by this project.

1.3 TESTING AND BALANCING - EXTENT OF WORK:

A. This work incorporates a confirming checkout of construction work, an individual component activation and an overall system activation into one work program which shall serve as the transition period from the Contractor's job to Owner's facility.

B. The TAB Contractor shall be skilled in the operation and manipulation of systems and in the direction of parties involved in the work.

C. Conduct and participate in the startup and shakedown of all mechanical systems installed and modified in this contract; test adjust and balance these systems to obtain optimum performance at a level which minimizes the required energy input, prepare and submit a complete report of work done and the final system condition obtained, participate in the instruction of Owner's personnel in the proper operation of systems and equipment.

D. Involves all new construction and those elements of existing construction which are affected by this project.

1.4 QUALIFICATIONS OF SYSTEM TAB TEAM:

A. Representatives of the General Contractor, Mechanical Contractor, etc., and Electrical Contractor shall be available on a daily basis through the adjustment period. These men shall be experienced journeymen with prior experience in system operation and with specific experience on the construction of this project.

B. Balancing shall be done by an independent firm specializing in this work. A definition of independent shall mean the firm is not associated with any engineering, contracting, or manufacturing firm and derives its income solely from testing, adjusting and balancing mechanical systems. Firm must be AABC or NEBB certified.

C. The balancing work including air and hydronic portions shall be performed by the same firm having total responsibility for the final testing, adjusting and balancing of the entire system. A principal of the firm shall be directly involved in the project.

D. The independent testing and balancing firm shall furnish all necessary tools, scaffolding and ladders that are required and shall provide all required instruments, take all readings and make all necessary adjustments.

E. After all tests and adjustments are made a detailed written report shall be prepared and submitted for review, and shall bear the signature of the professional supervising the work. Final acceptance of this project will not be made until a complete and satisfactory report is received. Furnish two copies of the report.

PART II - EXECUTION, SYSTEM STARTUP

2.1 PRE-STARTUP INSPECTION:

A. The pre-startup inspection of all systems shall provide for verifying that each piece of equipment is properly installed and prepared for startup.

B. All pertinent items shall be checked, including but not necessarily limited to the following:

1. Removal of shipping stops.

2. Vibration isolators properly aligned and adjusted.

3. Flexible connections properly aligned.

4. Belts properly adjusted.

5. Belt guards and safety shields in place.

6. Safety controls, safety valves and high or low limits in operation.

7. All systems properly filled.

8. Filters in place and seal provided around edges.

9. Fire dampers and smoke dampers properly installed and linked. Access doors provided for every damper.

10. Pressure and temperature gauges installed.

11. All test stations and measuring devices installed.

12. Initial lubrication of equipment is complete.

13. Filters and strainers are clean.

14. Motor rotations are correct.

15. Voltages match nameplate.

16. Control system is in operation.

17. All interlocks are wired and verified.

18. All controls have been connected and verified.

19. All valves, dampers and operators are properly installed and operating.

20. All ductwork is installed and connected.

21. All other items necessary to provide for proper startup.

2.2 FIRST RUN INSPECTION:

A. Recheck all items outlined in pre-startup inspection to insure proper operation.

B. Check the following items:

1. Excessive vibration or noise.
2. Loose components.
3. Initial control settings.
4. Motor amperages.
5. Heat buildup in motors, bearings, etc.
6. Control system is properly calibrated and functioning as required.
7. Chiller settings.

C. Correct all items which are not operating properly.

2.3 SYSTEM OPERATION INSPECTION:

A. Observe mechanical systems under operating conditions for sufficient time to insure proper operation under varying conditions, such as day-night and heating-cooling.

1. Periodically check the following items:

2. Strainers and filters.

3. Visual checks of air flow for "best guess" settings for preparation for system air balancing under section applying.

4. Control operation, on-off sequences, system cycling, etc.

5. Visual checks of water flow, seals, packings, safety valves, operation pressures and temperature.

6. Cleaning of excessive oil or grease.

7. Dampers close tightly.

8. Valves close tightly.

9. System leaks.

10. All other items pertaining to the proper operation of the mechanical system whether specifically listed or not.

PART III - EXECUTION - TESTING AND BALANCING

3.1 TOTAL MECHANICAL SYSTEM BALANCE:

A. The mechanical systems balance involves elements of the work of the General Contractor, the Electrical Contractor, the Mechanical Contractor, the Sheet Metal Contractor and the Controls Contractor. Total system balance requires that all elements be not only individually correct, but also correct as a composite system. Therefore, participation of all parties shall be required in the test and balance procedure.

B. Prior to beginning work, a written description of the anticipated sequence of action shall be submitted to the Architect/Owner for review and comment.

C. The testing and balance specialist shall review the contract drawings during the bid period and shall advise the Architect of any modifications to the layout which may be needed to facilitate the balance procedure. Modifications will be incorporated into the contract by Addendum during the bidding period.

D. The test and balance specialist shall visit the project from time to time during the rough installation making a thorough inspection of those items which will affect his subsequent work. He shall advise the Contractor in writing with a copy to the Architect of any work required by the contract which is not being performed adequately. This is in addition to the regular inspection efforts of the Architect and Engineer. Particularly note needed valves, dampers, access doors, thermometers, pressure gauges, belts and drives, diffuser styles, strainers and filters, etc.

3.2 AIR SYSTEMS BALANCE:

A. Before any adjustments are made, check the systems for such items as dirty filters, duct leakage, filter leakage, damper leakage, equipment vibrations, correct damper operations, etc. Adjust all fan systems, major duct sections, registers, diffusers, etc., to deliver design air quantities within +5%. Individual air outlets, when one of three or more serve a space may have a tolerance of 10 percent from the average. Design static pressure is based on filters approximately 50% loaded with dirt. Pressure drop across filters during balancing shall be simulated to that condition. After balancing is completed check motor amperage with the filters clean.

B. Adjust supply, exhaust and recirculation air systems towards air quantities shown on drawings. Establish a proper relationship between supply and exhaust. Follow proportional balance procedures outlined by AABC and/or SMACNA for such work.

C. Distribution system shall be further adjusted to obtain uniform space temperatures free from objectionable drafts and noise within the capabilities of the system.

D. Exchange sheaves and/or belts as needed to adjust the RPM of all fans so they handle specified air quantity.

E. Verify the function of all Variable Frequency Drives and related controls.

3.3 HYDRONIC SYSTEMS:

A. Before any adjustments are made, clean strainers, check temperature control valve operation, check pump rotation, adjust pressure reducing valves, etc.

B. Using system flow meters, pressure gauges, and/or contact pyrometer, adjust the quantity of fluid handled by each pump and supplied to each coil, piece of radiation, heat exchanger, etc., to meet design requirements. Use proportional balance techniques to minimize system pressure requirements.

1. Remove and trim pump impellers where throttling exceeds 10% of adequate flow.

3.4 MAJOR EQUIPMENT: The Testing and Balancing Contractor shall work with the Controls Contractor and Electrician in placing heat exchangers, pumps, fans and other major equipment in operation. The factory representative of the equipment manufacturer shall also participate in a team effort to place the system(s) in operation, adapt to all anticipated operating modes and make adjustments as required to obtain correct operation. The Design Engineer and the Owner's Representative shall witness the final operating sequences.

A. Use proportional balance techniques so that in every case, at least one terminal valve is set for full flow at wide open, and at least one branch valve is wide open at full flow, others equivalent.

3.5 CONTROL SYSTEMS: The Testing and Balancing Contractor shall go through the entire control system with the Controls Contractor verifying proper operation of each and every device and the proper function of each system. Certify such effort in the report.

3.6 MISCELLANEOUS:

A. Observe and note all furnished thermal overload protection in the data sheets. If thermal overload protection is incorrect, the trade which furnished the overload devices shall furnish and install the correct size overload protection devices. It shall be the responsibility of the balancing firm to confirm that proper overload protection has been installed at the completion of the job.

B. Measure and set any special conditions such as minimum air quantities; coordinate outside air, return air and relief air damper operation; check and adjust outside and return air intakes so that the system will deliver substantially the same volume on either; make tests and record data as required in "REPORT" below.

C. All balancing devices, i.e. dampers and valves, shall be clearly marked as to the final balanced position. Plug all test holes, replace access doors and belt guards.

D. Upon request, based on perceived need, make 24-hour space temperature recordings. Any required rebalance of the system shall be performed without additional cost.

E. Upon request, a representative of the balancing firm performing the work shall demonstrate fluid flow quantities shown in the report by reading back outlets or terminals selected specifically or at random by the Design Engineer. It is understood that the operating mode of the system shall be the same for read-back as it was during balancing.

3.7 REPORT:

A. Provide a bound report in four copies containing a general information sheet listing instruments used, method of balancing, altitude correction, and manufacturer's grille, register and diffuser data.

B. Provide equipment data sheets listing make, size, serial number, rating, etc. of all mechanical equipment including fans, air controllers, pumps, motors, starters and drives. Operating data shall include rotational speed, inlet an outlet pressures, pressure drop across filters, coils, an other system components, pump heads, and measured motor current and voltage.

C. Balancing data sheets shall indicate the required and actual CFM of all supply, return and exhaust outlets or inlets, and be totaled and summarized by systems.

D. Hydronic balancing data sheets shall list required temperature or pressure differentials used for balancing coils, radiations, condensers, etc. Sheets shall show in comparison final as-balanced versus design values.

E. Include a reduced set of contract drawings with outlets marked for easy identification of the signation used in the data sheets.

F. Note any abnormal or notable conditions not covered in the above.

G. Keep a daily log of all work performed, with a list of work scheduled for each day and the workers on the job.

3.8 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230593

SECTION 230620.13 - HVAC PUMPS

PART I - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 “Motors, Drives and Electrical Requirements,” “General Piping and Fittings,” “Mechanical Insulation,” “System Commissioning, Testing and Balancing” sections apply to work of this section.

1.02 DESCRIPTION OF WORK:

A. Extent of HVAC pumps work required by this section is indicated on drawings and schedules, and by requirements of this section, including incidental work classified as "Best practices of the trade".

B. Types of pumps specified in this section include the following:

1. Base mounted, flexible coupled, horizontal end suction.

C. Refer to other Division 23 sections for vibration control and seismic anchoring of HVAC pumps.

D. Refer to Division 26 sections for the following work.

1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.03 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of general-use centrifugal pumps with characteristics, sizes and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications:

1. Firm with at least 5 years history of successful experience on projects of similar nature.

2. Licensed as a firm in the Contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the contractor.

4. All workmen employed on the project shall carry state licenses as journeymen or apprentice pipe fitters with additional certification for welders.

C. Codes and Standards: Comply with applicable sections, follow recommended practices.

1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI "Hydraulic Institute Standards".

2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 778 "Motor Operated Water Pumps".

3. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

4. State and Local Plumbing and Mechanical Code.

5. International Building Code/International Mechanical Code.

6. ASHRAE Handbook(s).

1.04 SUBMITTALS:

A. Product Data: Submit manufacturer's pump specifications, indicating source, brand, type, model and performance characteristics, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to HVAC pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Operation and Maintenance Data: Submit maintenance data and parts lists for each type of pump, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 23 “Operation and Maintenance Manuals.”

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Handle HVAC pumps and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged HVAC pumps or components; replace with new.

B. Store HVAC pumps and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

PART II - PRODUCTS

2.01 PUMPS:

A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.

2.02 CIRCULATING PUMPS, HEATING AND CHILLED WATER: (Base mounted, flexible coupled)

A. General: Furnish and install each pump complete with a spool piece and suction diffuser. See drawings for capacity and configuration.

B. Equipment:

1. Horizontal, End Suction Pump Product

a. Type: Horizontal shaft, end suction, single stage, for 175 psig maximum working pressure.

b. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, open type lubricable ball bearings, seal flush connection, drain plug, flanged suction and discharge.

c. Impeller: Bronze, fully enclosed, keyed to shaft.

d. Bearings: Open type grease lubricated ball bearings with zerk grease fittings.

e. Shaft: High strength carbon steel.

f. Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F maximum continuous operating temperature. Furnish spare mechanical seal.

g. Drive: Flexible coupling with coupling guard.

h. Baseplate: Fabricated steel with integral drain rim.

i. Motor: T-frame, drip-proof motor with lubricable ball bearings, zerk grease fittings, relief plugs, 1750 rpm. Premium Efficiency.

j. Provide each pump with a spool piece and suction diffuser to provide a smooth flow of water into the pump inlet, complete with strainer, adjustable support leg, and start-up strainer.

C. Acceptable Manufacturers: Subject to compliance with requirements, provide pumps of one of the following:

1. Aurora

2. Bell and Gossett
3. Armstrong

PART III - EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which HVAC pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF PUMPS:

A. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

B. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.

C. Support: Refer to Division 23 "Mechanical Sound, Vibration and Seismic Control" for support and mounting requirements of HVAC pumps.

D. Installation:

1. Mount each pump on a concrete pad. Grout the pump base with "Embeco" grout to insure a level and solid installation.

2. Install gauge sensing points as shown on detail.

3. Install spool piece between the suction diffuser and pump inlet to allow for sufficient room and insulation space.

4. Remove start-up strainer during final testing and balancing phase.

5. Check pump rotation.

6. Align pump during final test and balance phase.

7. Pipe drain to floor drain.

E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

F. Piping Connections: Refer to Division 23 HVAC piping sections. Provide piping, valves, accessories, gages, supports, and flexible connections as indicated.

3.03 ADJUSTING AND CLEANING:

A. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.

B. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

C. Refer to Division 23 section "System Testing and Balancing" for pump system balancing; not work of this section.

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.04 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230620.13

SECTION 230700 - MECHANICAL INSULATION

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections apply to work of this section.

B. Division 23, Section 23 00 00 - General Mechanical Requirements applies to work of this section.

1.2 SUMMARY:

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules as required by the current International Energy Code, and by requirements of this section. Use no asbestos in this work. Include restorations of insulations of damaged work including repair of damaged existing insulation due to new work.

B. Types of mechanical insulation specified in this section include the following:

1. Piping Systems Insulation:

   a. Fiberglass.
   b. Refrigerant Piping Insulation - Closed Cell Elastometric.

2. Ductwork System Insulation:

   a. Fiberglass.
   b. Rigid Flexible Wrap.

3. Equipment Insulation:

   a. Fiberglass.
   b. Flexible Unicellular.

C. Refer to Division 23 section "Supports and Anchors" for protection saddles, protection shields, and thermal hanger shields.

D. Refer to Division 23 section "Ductwork" for duct linings.

E. Refer to Division 23 section "System Identification" for installation of identification devices for piping, ductwork, and equipment.

1.3 QUALITY ASSURANCE:

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Installer’s Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's specifications and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Deliver insulation, coverings, cements, adhesives and coatings to site in containers with manufacturer's stamp or label affixed showing fire hazard ratings of products.

B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART II - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide mechanical insulation materials of one of the following (except as noted):

1. Armstrong World Industries, Inc.
2. Babcock and Wilcox Co., Insulating Products Div.
3. CertainTeed Corp.
4. Knauf Fiber Glass GmbH.
5. Manville Products Corp.
6. Owens-Corning Fiberglass Corp.
7. Pittsburgh Corning Corp.
8. Rubatex Corp.

2.2 PIPING INSULATION MATERIALS:

A. Preformed Fiberglass Piping Insulation: ASTM C 547. (Class 1 for use to 450^{o}F (230^{o}C); Class 2 for use to 650^{o}F (345^{o}C); Class 3 for use to 1200^{o}F (650^{o}C).

B. All insulation exposed to sunlight or installed outdoors shall be protected with two coats of Armstrong Wb Armaflex Finish.

C. Jackets for Piping Insulation: All purpose (ASJ) fire retardant jacket, ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

D. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.

E. Encase exterior fittings insulation with aluminum jacket with weather-proof construction.

F. Encase suction diffusers in a removable/replaceable insulating box.

G. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

H. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

I. Insulation Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.

J. Thermal Hanger Shields: constructed of 360 degrees insert of high density, 100 psi, water-proofed calcium silicate, encased in 360 degrees sheet metal shield. Provide assembly of same thickness as adjoining insulation

2.3 DUCTWORK INSULATION MATERIALS:

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1. Class 1 - 400°F (204°C); Class 2 - 400°F (204°C); Class 3 - 850°F (454°C); Class 4 - 1000°F (538°C); Class 5 - 1800°F (982°C); Class 1 - 10 lbs/ft^3; Class 2, 3 and 4 - 12 lbs/ft^3; class 5 - 20 lbs/ft^3.

B. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, Class B-4. Type 1 - resilient, flexible; Class B-1 - 0.65 lbs/ft^3; Class B-2 - 0.75 lbs/ft^3; Class B-3 - 1.0 lbs/ft^3; Class B-4 - 1.5 lbs/ft^3; Class B-5 - 2.0 lbs/ft3; Class B-6 - 3.0 lbs/ft^3; Type II - flexible; Class F-1 - 4.5 lbs/ft^3; Type III - semirigid; Class F-2 - 4.5 lbs/ft^3.

C. Jackets for Ductwork Insulation: ASTM C 921, Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient.

D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

E. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes ad similar compounds as recommended by insulation manufacturer for applications indicated.

2.4 EQUIPMENT INSULATION MATERIALS:

A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2 to 400°F, Class 3 to 850°F, Class 4 to 1000°F. (Class 1 - 400°F (204°C); Class 2 - 400°F (240°C); Class 3 - 850°F (454°C); Class 4 - 1000°F (538°C); Class 5 - 1800°F (982°C); Class 1 - 10 lbs/ft^3; Class 2, 3 and 4 - 12 lbs/ft^3; Class 5 - 20 lbs/ft^3.)

B. Flexible Fiberglass Equipment Insulation: ASTM C 553, B-4. (Type 1 - resilient flexible; Class B-1 - 0.65 lbs/ft^3; Class B-2 - 0.75 lbs/ft^3; Class B-3 - 01.0 lbs/ft^3; Class B-4 - 1.5 lbs/ft^3; Class B-5 - 2.0 lbs/ft^3; Class B-6 - 3.0 lbs/ft^3; Type II - flexible; Class F-1 - 4.5 lbs/ft^3; Type III - semirigid; Class f-2 - 4.5 lbs/ft^3.)

C. Flexible Unicellular Sheet Insulation: ASTM C 534. (Type I - tubular; Type II - sheet. For use between -40°F (-40°C) and 200°F (93°C) only.)

D. Jackets Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

E. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by the insulation manufacturer for applications indicated.

F. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

2.5 PIPING SEALANT THROUGH WALLS: See also Section Mechanical Firestopping.

A. Sealant shall be a two-part foamed silicone elastomer equal to Dow Corning 3-6548 Silicone RTV foam or equivalent by 3M or "Spec Seal" by STI. Sealant shall be applied at any piping of pipe or duct penetration through fire or smoke walls to prevent air from passing through the opening.

B. Sealant cell structure, foamed in place, shall be U.L. classified and shall meet the smoke development and fuel contribution ratings specified. Sealant shall be stable at extreme temperatures, and shall effectively confine such hazards as fire, smoke and gases.

C. Sealant required at any fire/smoke wall penetration to be according to approved detail for each specific wall assembly. Contractor shall submit detail for engineer approval.

2.6 PIPE JACKETING:

A. Provide and install jacketing for all insulated pipe exposed in building and in mechanical rooms, fan rooms, high temperature water converter room, chiller room, passage ways. This in addition to standard foil on Kraft jacketing (ASJ).

1. Domestic water, heating water, chilled water, other insulated piping.

a. PVC sheets, 0.030" thickness.
b. PVC formed fitting covers.
c. Solvent welded joints and seams.
d. (Provide for removal and expansion.)

B. All joints and seams caulked and sealed water tight.

C. Color of jacketing shall be white.

2.7 COATING OF CHILLED WATER PIPING: After fabrication assembly and installation of blacksteel chilled water piping (copper and galvanized steel excluded), scrape and brush piping free of scale, dirt and loose material, and wipe clean with solvent moistened cloth.

A. Using brush or roller coat entire piping surfaces with prime and finish coats of a water based vinyl acrylic system equivalent to the RustOleum "RustOCrylic" 5700 system or equivalent by SherwinWilliams. System includes red primer (5769) grey primer (5781) and black finish coat (5779). Seek a final film thickness in the 4-6 mil range.

B. Allow coating to dry and harden thoroughly before applying insulations.

2.8 FIRE/SMOKE ENCASEMENT:

A. Any and all non plenum rated PVC, and any other plastic piping located in return air and supply air plenums shall be encased in rated flame and smoke system. The encasement shall be equal to Firemaster "Plastic Pipe Fire Protection System." The enclosure shall meet all codes.

PART III - EXECUTION

3.1 GENERAL:

A. Piping insulation shall be fiberglass one-piece preformed pipe insulation, class related to temperature, with all purpose (ASJ) fire retardant jacket, additional jacketing as noted.

B. Fittings and valves shall be insulated and covered with Zeston covers.

C. All cold water, chilled water, roof drains or any other lines upon which condensate moisture could form, shall have a vapor-proof jacket.

D. Fire and smoke hazard for a complete insulation system shall not exceed:

1. Flame spread - 25
2. Fuel contribution - 50
3. Smoke development - 50

E. Hangers shall not contact pipe where pipe is specified to be insulated.

3.2 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.3 PLUMBING PIPING SYSTEM INSULATION:

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions strainers check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, fire protection piping, and pre-insulated equipment.

B. Cold Piping:

1. Application Requirements: Insulate the following cold plumbing piping systems:

a. Potable cold water piping, chilled domestic water supply and return.

b. Interior above-ground storm water piping, including roof drain, deck drain and landscape drain piping.

c. Plumbing vents within 6 lineal feet of roof or wall outlet.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass with all service jacket, self sealing lap:
b. 1" thickness, taped and sealed joints.

C. Hot Piping:

1. Application Requirements: Insulate the following hot plumbing piping systems:

a. Potable hot water piping.

b. Potable hot water recirculating piping.
c. Hot drain piping (where indicated).

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass with all service jacket, self-sealing lap: 1" thick for pipe sizes up to and including 6", 1-1/2" thick for pipe sizes over 6".

3.4 HVAC PIPING SYSTEM INSULATION:

A. Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan; on heating piping beyond control valve, located within heated space; on condensate piping between steam trap and union; and on unions, flanges strainers, flexible connections, and expansion joints.

B. Cold Piping 40^{O}F (4.4^{O}C) to Ambient:

1. Application Requirements: Insulate the following cold HVAC piping systems:

a. HVAC make-up water piping.

b. All HVAC chilled water piping.

c. Condensate drain piping from cooling coils.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1" thick for pipe sizes up to and including 1-1/2", 1-1/2" thick for pipe sizes over 1-1/2".

C. Hot Pressure Piping (to 250^{o}F):

1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 100 psi, water piping up to 200 degrees F).

a. HVAC hot water supply and return piping, valves and fittings.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".

D. Insulation of Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing. Use only impermeable insulations (foam glass). Cover with aluminum jacketing 0.02" minimum thickness.

3.5 DUCTWORK SYSTEM INSULATION:

A. Insulation Not Required: Do not insulate lined ductwork.

B. Hot, Cold and Dual Temperature Ductwork:

1. Application Requirements: Insulate the following ductwork:

   a. Outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet.

   b. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet. Insulate neck and bells of supply diffusers.

   c. HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet: except omit insulation on return ductwork located in return air ceiling plenums.

   d. HVAC plenums and unit housings not pre-insulated at factory or lined.

   e. HVAC relief air plenums and ductwork.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:

   a. Rigid fiberglass: Class 1, 1-1/2" thick, increase thickness to 2" in machine, fan and equipment rooms.

   b. Flexible Fiberglass: Type 1, Class B-4, 1-1/2" lb/ft^3 density, 1-1/2" thick, application limited to concealed locations.

C. High and Medium Velocity Duct: Insulate externally with type 1, class B-4 (1-1/2 lb/ft^3 density) 1-1/2" thick fiberglass faced duct wrap with factory applied foil scrim Kraft facing U.L. 723 label.

D. Duct Insulations:

1. Wrap insulation snugly on the ductwork such that maximum thickness is maintained. Butt all circumferential joints and overlap longitudinal joints a minimum of 2". Adhere insulation with 4" strips of Insulation Bonding Adhesive, at 8" on center.

2. On circumferential joints, staple the 2" flange of the facing with 9/16" flare-door staples on 6" centers and taped with minimum 3" wide foil reinforcing Kraft tape. Tape all pin penetrations or punctures in the facing.

3.6 EQUIPMENT INSULATION:

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:

2. Roof drain bodies.

3. Factory insulated surfaces do not need to be field insulated.

4. Chilled water pump suction diffuser.

B. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:

1. Fiberglass: 2" thick for surfaces above 35°F (2°C) and 3" thick for surfaces 35°F (2°C) and lower.

2. Cellular Glass: 3" thick for surfaces above 35°F (2°C) and 4-1/2" thick for surfaces 35°F (2°C) and lower.

3.7 INSTALLATION OF PIPING INSULATION:

A. General: Install insulation products in accordance with the manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. Provide neatly beveled edge at all terminations and interruptions of insulation.

I. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

J. Saddles and Shields:

1. General: Except as otherwise indicated, provide protection saddles or thermal hanger shields with protection shields under all piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and thermal shields for exact fit to mate with pipe insulation.

2. Protection Saddles: See section Supports and Anchors for saddle. Fill interior voids with segments of insulation matching adjoining insulation.

3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation. Use on pipes 1-1/4" and smaller. Use with thermal hanger shields for pipes 1-1/2" and larger.

4. Thermal Hanger Shields: High density calcium silicate encased in 360 degrees sheet metal shield. Provide assembly of same thickness as adjoining insulation. Use on pipes 1-1/2" to 8".

3.8 INSTALLATION OF DUCTWORK INSULATION:

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

E. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

F. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

G. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

H. Corner Angles: Install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

3.9 INSTALLATION OF EQUIPMENT INSULATION:

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Apply insulation using staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

E. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

F. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

G. Do not insulate over handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

H. Provide removable insulation sections to cover parts of equipment which must be opened

periodically for maintenance: including chilled water pumps, balancing valves, flanges, and accessories.

3.10 EXISTING INSULATION REPAIR:

A. Repair damaged sections of mechanical insulation damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

3.11 PROTECTION AND REPLACEMENT:

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during construction period to avoid damage and deterioration.

3.12 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230700

SECTION 230800 – COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

01 08 00 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

230000	General Mechanical Requirements
230100	Operation and maintenance manuals
230505	Mechanical Firestopping.
230513	Motors, Drives and Electrical Requirements for Mechanical Work
230523	General Duty Valves for HVAC Piping
230519	Thermometers and Pressure Gauges
230523	Valves
230529	Mechanical Supporting Devices
230548	Mechanical Sound, Vibration and Seismic Control
230553	Mechanical Identification
230593	Testing, Adjusting, and Balancing for HVAC
230620	HVAC Pumps
230700	Mechanical Insulation
230900	Mechanical Control Systems
230923	Direct Digital Control Systems
230933	Electrical Control Systems
231123	Natural Gas Piping
232113	General Pipes and Fittings.
232113	Hydronic Piping and Specialties
232500	Chemical Water Treatment, Filters and Equipment
233100	Ductwork
233300	Ductwork Accessories
233423	Power Ventilators
233616	Air Terminal Units
233713	Air Outlets and Inlets
234116	Air Filters
235234	Boilers
236411	Air Cooled Packaged Chiller
237300	Packaged Air Handling Equipment.
238200	Terminal Heat Transfer Units
238216	Heating and Cooling Coils

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 010800, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 010800, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Hydronic Piping Systems-232113						
Pressure Testing						
Cleaning						
System Readiness Checklist		CA Provided				
Chemical water treatment -232500						
Manufacturer Start-up Documentation for glycol make up unit						
System Readiness Checklist		CA Provided				
HVAC Pumps-(HWP,CHWP)						

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A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
230620						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Power Ventilators (EF)-233423						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Packaged Air Handling Equipment(AH, MAU, BCU)-237300						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Air Terminal Units(VAVR)-233616						
Test and demonstrate VAV to ductwork are leak-tight						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Boilers-235234						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Air Cooled Packaged Chiller-236411						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Ductwork -233100						
Ductwork Pressure Test		n/a				

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A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Temperature Control Systems-230900-923						
Graphical interface plan		n/a				
Point schedule		n/a				
System wiring and point to point diagrams		n/a				
Floor plan of control and monitoring equipment		n/a				
Point-to-point verification						
Sensor calibration						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Testing, Adjusting, and Balancing-230593						
TAB Agenda						
TAB Meeting Minutes						
Preliminary TAB Report						
System Readiness Checklist		CA Provided				
Terminal Heat Transfer Units-238200						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.
B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.
C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.
D. Indicates that CA has received and approved proposed installation and start-up documentation.
E. Date the completed documents are received by the CA from the responsible Contractor.
F. Indicates that CA has received and approved completed documentation.
G. Notes on status of forms, irregularities and rework needed.

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Hydronic Piping 232113
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided for all components.
- Equipment and systems are labeled per project documents.
- Piping installed with slope to drain.
- Hose end drain valves installed at all low points.
- Air vents with valves installed at all high points of the hot water systems.
- Automatic air vents piping installed for drainage to nearest drain.
- Unions installed on all equipment requiring disconnects for servicing.
- Dielectric unions installed on all dissimilar materials per specifications.
- Expansion joints and loops are installed as needed and per manufacturer’s recommendations.
- Pressure and temperature gages installed at all specified points.
- Pressure and temperature gage ranges per specifications.
- P/T ports installed at locations specified.
- Relief valves installed on all pressure vessels as specified.
- Strainers installed at all specified locations including blow-off valve and cap.
- Air separators, expansion tanks and suction diffusers installed.
- Water treatment system installed per project documents.
- Heat trace installed where specified.
- Valves provided and installed per specification in regards to connection style and size.
- Valves installed for area and group isolation, maintenance isolation and service disconnects.
- Valves installed with stems oriented up.
- Control valves installed and wired to control system.
- All specified equipment, piping, valves, pump bodies, drains, unions are insulated per specification - removable insulation installed as specified.
- All valves tagged with number and function, valve index posted.
- Pipes across traffic areas provided with protection.
- Piping is shielded to prevent water leakage above electrical equipment/panels.
- Mechanical supporting devices installed at specified locations and spacing

Start-Up:

- Commissioning Authority notified for witness of start-up (cleaning, flushing, etc.).
- Expansion tank pressures have been checked and set per engineer’s guidance.
- Water pipe pressure tested and accepted. Attach reports.
- Water piping flushed and cleaned and chemically treated per specifications and accepted. Attach reports.
- Strainers cleaned per specification procedure prior to balancing.
- All air has been removed/bleed from the system prior to balancing.
- Water chemical treatment complete, treatment system operational, attach treatment report.
- Control valves verified operational.

Readiness:

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Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Hydronic System Test, Flush & Clean Logs 232500

Piping System Test and Flush Log

Instructions: Listed below are systems requiring pressure testing and flushing per the specification. The responsible contractor for each system is to date and sign when each activity is completed.

Project team to be notified 3 days prior to flushing/charging to allow for scheduling of witnessing of activities.

System	Date	Activity - Test/Flush	Executing Contractor	Contractor	Witness
HYDRONIC SYSTEM					
Heating Water		Pressure test			
Heating Water		System flush and cleaned per spec 23 20 00			
		1st flush			
		AH/BCU/VAVR valves open for 1st flush			
		2nd flush with cleaning solution - 4 hr minimum			
		AH/BCU/VAVR valves open for 2nd flush			
		3rd flush - blow down strainers - 1 hr minimum			
		AH/BCU/VAVR valves open for 3rd flush			
		Prior to inhibitor charging of system blow-down all strainers, dead legs and system low points.			
Heating Water		System charged to required levels and circulated / valves open to AH/BCU/VAVR Test report attached			

NOTE: All flushing and system charging activities to be executed with all AHU and AHU heating/cooling/control valves OPEN.

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HVAC Pumps 230620
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Pumps installed, leveled, grouted and plumbed.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Associated piping, shutoff valves, control valves and insulation are complete.

All balancing and check valves, gages and thermometers are installed per project documents.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.

External controls installed.

All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

Commissioning Authority notified for witness of start-up.

Voltage and phase has been verified.

Pumps have been properly adjusted and aligned.

Pumps have been lubricated.

Motor operation and rotation verified.

Internal controls and safeties verified operational.

External controls verified operational.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers’ checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Air Handling Unit 237300
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided.
- Equipment and systems are labeled per project documents.
- Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- Inspection and access doors are operable.
- Condensate drain with P-trap and cleanout is installed and unobstructed.
- Associated gas piping, shutoff valves, regulators, flex line and drip legs complete
- Dampers and actuators installed and verified operational.
- Temporary filters have been removed, new installed, spares provided.
- Ductwork is complete including access to all serviceable components.
- Pipe and conduit penetrations have been caulked.
- Units are level and secured.
- Plenum and casings have been cleaned.
- Coil fins have been combed out if necessary.
- Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- External controls installed.
- All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

- Commissioning Authority notified for witness of start-up.
- Voltage and phase has been verified.
- Motor operation and rotation verified.
- Belts and/or couplings have been properly adjusted.
- Unit has been lubricated.
- Internal controls and safeties verified operational.
- External controls verified operational.

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Readiness:

Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Blower Coil Units 237300
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided.
- Equipment and systems are labeled per project documents.
- Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- Inspection and access doors are operable.
- Condensate drain with P-trap and cleanout is installed and unobstructed.
- Associated gas piping, shutoff valves, regulators, flex line and drip legs complete
- Dampers and actuators installed and verified operational.
- Temporary filters have been removed, new installed, spares provided.
- Ductwork is complete including access to all serviceable components.
- Pipe and conduit penetrations have been caulked.
- Units are level and secured.
- Plenum and casings have been cleaned.
- Coil fins have been combed out if necessary.
- Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- External controls installed.
- All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

- Commissioning Authority notified for witness of start-up.
- Voltage and phase has been verified.
- Motor operation and rotation verified.
- Belts and/or couplings have been properly adjusted.
- Unit has been lubricated.
- Internal controls and safeties verified operational.
- External controls verified operational.

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Readiness:

Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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VAVR w/Hydronic Reheat 233616
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Equipment mounted per project documents. Units are level and secured.

Inspection and access doors are operable.

Associated piping, shutoff valves, control valves and insulation are complete.

Dampers and actuators installed and verified operational.

Velocity probes installed, tubing connected to controller.

Ductwork is complete including access to all serviceable components.

Plenum and casings have been cleaned.

Coil fins have been combed out if necessary.

External controls installed and complete.

Terminal units provided with a sound attenuating insulated ductwork downstream of units.

Terminal units provided with a minimum of 3 times duct diameter of straight run ductwork at inlet of units.

Start-Up:

External controls verified operational.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers’ checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Exhaust Fans 233423
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Unit mounted per project documents.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Inspection and access doors are operable.

Curb mounted fans are bolted to the curb and sealed per project documents.

Back draft damper installed and verified operational.

Speed controllers installed as needed for balancing.

Ductwork is complete including access to all serviceable components.

Plenum and casings have been cleaned.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.

External controls installed.

All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

Commissioning Authority notified for witness of start-up.

Motor operation and rotation verified.

Unit has been lubricated.

Belts and/or couplings have been properly adjusted.

Internal controls and safeties verified operational.

External controls verified operational.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers’ checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Boilers – Gas Fired 235234
System Readiness Checklist (Preliminary Version)
Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Unit mounting per project documents.

Inspection and access doors are operable.

Associated piping, shutoff valves, control valves and insulation are complete.

Pressure relief installed, piped to drain (or fluid recovery) and sized per project documents.

Condensate drain with P-trap and cleanout is installed and unobstructed.

Associated gas piping, shutoff valves, regulators, flex line and drip legs complete

All gages and thermometers are installed per project documents.

Stacks and breaching complete, sealed and drained properly.

Dampers and actuators installed and verified operational.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate, disconnect labeled.

External controls installed and verified.

All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

Commissioning Authority notified for witness of start-up.

Boiler assembly has been flushed and hydrostatically tested per project documents.

Motor operation and rotation verified.

Belts and/or couplings have been properly adjusted.

Internal controls and safeties verified operational.

External controls verified operational.

Boilers have been adjusted for best efficiency. Attach report.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers’ checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.
Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Air Cooled Chillers-236411
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment labeled with equipment number.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Inspection and access doors are operable.

Associated piping, shutoff valves, control valves and insulation are complete.

Unit has been lubricated.

Belts and/our couplings have been properly adjusted.

Coil fins have been combed out if necessary.

Unit disconnect within sight of unit, power available to unit, disconnect labeled.

External controls installed

Internal controls and safeties installed

All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

Commissioning Authority has been notified for witness of start-up.

Motor operation and rotation verified.

Internal controls and safeties verified operational.

External controls verified operational.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturer’s checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Ductwork Systems 233100
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Ductwork is complete including access to all serviceable components.

Duct access doors provided per the project requirements.

All ductwork installed per required SMACNA standards.

Plenum and casings have been cleaned per the project requirements.

Balancing dampers provided at all duct take-offs to diffusers, grilles, and registers.

Fire/smoke damper shafts marked with blade position prior to installation.

Fire/smoke damper doors labeled and motors accessible for service (replacement).

All ductwork has been thoroughly cleaned of debris, dust, marks, tags and labels removed.

All ductwork is sealed as specified.

All specified equipment and ductwork is insulated.

Start-Up:

Commissioning Authority notified for witness of start-up.

Ductwork pressure tested to project requirements.

Fire dampers verified operational.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers’ checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Temperature Control 230923
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided for all components.
- All control devices (actuators, sensors, etc.) have been provided per the Project Documents.
- Outdoor air sensor located to minimize external influences of heat or cool.
- All sensors located per contract documents.
- Control wire installed neatly in cable trays, D-rings, conduit, cable tied or plenum rated per Project Documents.
- Control wiring, panels and all system components are permanently labeled, including point address designation, system reference and descriptions.
- Front end computer and peripherals provided per project document specifications.
- Printer provided per project document specifications.
- Surge protection and battery back-up devices installed per project documents.
- External communication connected.

Start-Up:

- Commissioning Authority notified for witness of start-up.
- System graphics are complete per graphical interface plan (showing all devices controlled, all adjustable points shown, all specified components), accurate (reflects actual field/unit installation, end-to-end verification of points done) and functional.
- Point to point testing and sensor calibration is complete and checkout forms complete with copy submitted.
- Room temperature and other set points configured per Project Documents and owner’s direction.
- Operating schedules have been set up per Project Documents or owner’s direction
- Alarms have been programmed per Project Documents and owner’s direction.
- Access Security levels have been set up per Project Documents and owner’s needs.
- Trend logs have been set up per Project Documents and/or as directed by the CA.
- Minimum OA %, from balancer, provided on graphics as permanent reference value.
- Network connection is complete, the central operator terminal has been updated and remote monitoring of the system has been tested.

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Readiness:

Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Testing, Adjusting, and Balancing 230593
System Readiness Checklist (Preliminary Version)

Installation:

HVAC related System Readiness Checks completed regarding all installation activities.

Start-Up:

HVAC related System Readiness Checks completed regarding all start-up activities.

Balancing agenda provided to engineer. Provide copy to CA for review.

Pre-balance conference complete.

System Readiness:

HVAC equipment operation verified

Construction filters removed, clean filters installed, damper position and operation checked prior to balancing. Air balance due with filters simulated as ½ dirty.

Bathrooms are negative relative to other areas.

Rooms pressures are positive while allowing for door closure in economizer mode.

Overall building pressure checked with outside air at 100% to assure adequate relief.

Relief damper operation has been checked to assure dampers open and close as needed.

Air balanced prior to water balance.

Hydronic system and strainers has been cleaned and treated prior to balancing.

Expansion tanks are properly pressurized and not water logged.

Air vents installed and operational, water system balanced with no air in system.

Noise and vibration has been checked and adjusted as necessary.

Final damper and speed controller permanently marked for final balancing positions.

All systems balanced to specified design criteria except as approved by mechanical engineer.

Preliminary report has been provided on approved forms with data specified.

List of control minimum OA damper positions in report and provided to controls contractor.

All defects/ deficiencies have been noted to CA/ engineer during testing, included in report.

All TAB procedures are complete and ready for the system balance demonstration. The TAB contractor will demonstrate proper balance by measuring and verifying a percentage of the systems as selected and witnessed by the Commissioning Authority.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Unit Heaters – Hydronic 238200
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Unit installed and mounted per project document.

Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.

Associated piping, shutoff valves, control valves and insulation are complete.

Coil fins have been combed out if necessary.

Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.

External controls installed.

All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency

Start-Up:

Commissioning Authority notified for witness of start-up.

Motor operation and rotation verified.

Internal controls and safeties verified operational.

External controls verified operational.

Operating parameters measured and recorded.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed and signed copy of all manufacturer’s checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A System Description	B Responsible Contractor	C Proposed Test Forms Received	D OK	E Testing Complete	F OK	G Notes
Heating Water System						
Air Handling Units						
Terminal Units						
Exhaust Fans						
Air Distribution System						
Temperature Control System						
Balancing Air and Water						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Heating Water Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1) Boilers
   a) Demonstrate operation of all boiler control functions.
   b) Simulate alarm conditions and demonstrate all safeties and alarm reporting.
   c) Demonstrate boiler efficiency, record all operating parameters.
   d) Demonstrate boiler modulation and temperature control.
   e) Demonstrate BCS Interface.

2) Pumps
   a) Pump performance, demonstrate at least one point on the pump curve.
   b) Verify motor operation and parameters.
   c) Demonstrate hand/off/auto operation.
   d) Demonstrate lead/lag operation.

3) Valves
   a) Demonstrate control valve operation and indication.
   b) Measure and confirm water flow.

4) Appurtenances
   a) Demonstrate proper expansion tank charge and makeup water PRV setting.
   b) Demonstrate operation of chemical treatment system.
   c) Demonstrate proper glycol levels at 25% of the coils by sampling water at the coils.

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Air Handling Units
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	Up to 50%

Functional Tests:

1) Unit Operation
   a) Demonstrate operation of all features and functions
   b) Simulate all alarm conditions and demonstrate all safeties and alarm reporting.
   c) Demonstrate freeze protection mode in hand and auto
   d) Demonstrate smoke detector shutdown in hand and auto
   e) Demonstrate fan HOA functions
   f) Demonstrate VFD HOA and by-pass functions
   g) Demonstrate modulation and temperature control.
   h) Demonstrate BCS Interface

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Terminal Units
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	Up to 50%

Functional Tests:

1) Unit Operation
   a) Demonstrate operation of all features and functions.
   b) Simulate alarm conditions and demonstrate all safeties and alarm reporting.
   c) Demonstrate modulation and temperature control.
   d) Demonstrate BCS Interface.

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Air Distribution Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Preliminary Activities:

The contractor will be responsible for marking the motorized smoke control damper shaft ends with the damper blade orientation and providing access (ladders, lifts, etc.) to the motorized dampers during testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	Up to 25%

Duct Systems
1) All specified duct leakage tests.

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Fire and Smoke Control
1) Demonstrate and document the operation (open/close) of all motorized Fire/Smoke Dampers.

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Exhaust Fans
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1) Exhaust fans
   a) Demonstrate operation of all features.
   b) Demonstrate on/off control and any interlocks.
   c) Demonstrate building control system Interface.

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Balancing Air and Water Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	10%	N/A

Functional Tests:

1) Perform measurements to demonstrate air and water side balance meets design tolerances.
2) Perform measurements to demonstrate building pressurization in various modes of operation.
3) Perform measurements to demonstrate room pressurization in various modes of operation.

The testing and air balancing contractor will be required to demonstrate a properly balanced system by measuring and verifying the specified percentage of the previously balanced systems as selected and witnessed by the Commissioning Authority. The TAB contractor will also demonstrate the proper pressure relationship of the spaces to each other and the outside.

In the event that the testing and balance verification values are off by more than 10% of original testing values, the balancing contractor will be required to readjust the systems to the satisfaction of the owner and design team.

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Building Control System
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule - B details the various methods of accomplishing functional testing.

Preliminary Activities:

Prior to any graphical system development, the control contractor is to submit a System Setup Outline to the Commissioning Authority and Owner/Owner's representative for approval. The outline should describe the graphics to be provided along with a detailed list of the individual points to be displayed, screen linking, security levels, alarm management, schedules, trending, animation strategies, navigation, etc.

Trend logs shall be entered per the direction of the CA to support demonstration of operation as outlined and for the performance period.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1&2	Contractor	Contractor	N/A	10%

The testing under this method is part of the control contractor's base-line responsibilities of the contract and is not additional scope related to commissioning.

1) Point-to-point testing of monitored and controlled points
   a) Point-to-point tests.
   b) Component level testing and verification.
   c) Sensor calibration to reference standard of all analog points.
2) System acceptance test plan
   a) Test plan to verify all aspects of sequence of operations

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	Up to 50%

The CA will develop a series of functional performance tests to be conducted by the contractor and as outlined below. Part 4 of this specification section includes sample functional test documents. These are samples only and do not reflect all functional test requirements. The contractor will conduct the functional tests and turn over the completed functional test documentation and trend logs to the CA. The CA will re-conduct a portion of the tests. The contractor shall include time in their bid to support the CA during this activity. This support does not include the normal testing and verification as noted above.

The control contractor shall make available to the CA, at no additional cost, a method of interfacing with the control system at the building site. This interface shall be made available regardless of if a permanent local work station is specified in the contract documents or not. The interface shall be made available for the duration of the commissioning process and all commissioned systems are accepted. The control contractor shall also make available to the CA, at no additional cost, a method of remotely accessing the

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system during the commissioning process and up to one year after system acceptance. Remote and local access shall include all software, licensing, software keys and anything else required to facilitate full access to the system. The local and remote interfaces shall include all contract required interfaces including, but not limited to, all graphics, trends and alarms. The CA shall be given an account with full security access privileges to the system.

The contractor will review the test plan provided by the CA to verify the following:

1. The functional tests will not endanger the equipment or personnel in the facility.
2. The functional tests can be performed per the plan with the installed interface and equipment.

Functional Tests:

1) Functional testing to demonstrate proper operation of ALL modes of operation of all systems under control of the automatic temperature control system and as described in the sequence of operations including but not limited to the following equipment:

   a) Air Handlers
   b) Blower Coils
   c) VAV Terminal Units
   d) Variable Speed Drives
   e) Exhaust Fans
   f) Hydronic Pumping Systems
   g) Boilers
   h) Chillers
   i) Integrated systems (generator, fire, etc.)
   j) Any control of existing systems

2) Functional testing to demonstrate proper operation of ALL modes of operation of all systems under control of the automatic temperature control system and as described in the sequence of operations including but not limited to the following modes:

   a) Unoccupied mode
   b) Unoccupied limits
   c) Occupant override mode
   d) Optimal Start
      i) Heating mode
      ii) Cooling mode
   e) Warm-up mode
   f) Occupied mode
      i) Heating mode
      ii) Cooling mode – including economizer
   g) Electric and Gas demand limiting

3) Functional testing to demonstrate operation of all sub-systems under control of the automatic temperature control system and as described in the sequence of operations including but not limited to the following categories:

   a) Fan control
   b) Pump control
   c) Interlocked fan operation
   d) Zone temperature control
   e) Thermostatic control

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f) Automatic damper control and modulation
g) Room air pressure control
h) Flow control
i) Control valve open/close and modulation
j) Heating/cooling capacity
k) Alarm monitoring
l) Graphical user interface

4) System stability and control verification via trending (performance period). Trend logs to be set up by control contractor to demonstrate system performance, to include, but not limited to the following:

a) Zone temperature control
b) Morning warm-up verification
c) Optimum start-stop verification
d) Hot water temperature control
e) Hot water pressure control
f) Chilled water temperature control
g) Chilled water pressure control
h) Discharge air temperature control
i) Discharge air pressure control
j) Building static pressure control

5) Functional testing of all equipment protections monitored by the automatic temperature control system, safeties and alarms including but not limited to the following modes:

a) Freeze protection
b) Smoked detector, fire alarm shutdown for air handling equipment
c) Boiler protections and alarms
d) Chiller protection and alarms
e) Dirty filter status
f) Pump failure and alarms
g) VFD alarm
h) Fan failure

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	Responsible Contractor	Proposed Agenda Received	OK	Training Performed	OK	Closeout Form Received	OK	Notes
Heating water system, boilers, pumps								
AHUs and Terminal units								
Exhaust fans								
Air distribution system								
Temperature Control Systems								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Building IAQ flush out completed and accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

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Heating Water Systems Sample Functional Test Procedure
System Glycol

Procedures:

1. Verify all system have been flushed and charged with glycol per the project requirements.
2. Randomly select 25% of heating and cooling coils and sample hydronic water at the coils
3. Verify glycol level meets project requirements.
4. Record readings.

Chilled water requirement::
Heating water requirement::

Data Sheet

Unit	Glycol Level	Unit	Glycol Level	Unit	Glycol Level	Unit	Glycol Level

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Ductwork Systems Sample Functional Test Procedure
Fire/Smoke Dampers

Procedures:

1. Locate, identify and number all smoke/fire dampers indicated on the drawings.
2. Verify each fire/smoke damper has been installed, access is provided, duct access doors are installed, damper is labeled and shaft is marked. Indicate observations in the provided Observations column. Reference key provided below table.
3. Verify fire/smoke dampers open and close as power is applied (as applicable). Indicate test results in the provided Test column.

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Fire Damper Data Sheet

No	Dwg. No.	Grid Location	Type	Description	Observation						Test		N	Comment
					I	A	D	L	M		O	C		

Notes:
1 Access through grill
2 Access via flex duct
3 Direct observation through access door
4 Observation of set screw as reference

Key:
I Installed
A Access to damper motor
D Door for access in duct
L Label on access door
M Marked shaft
N Notes
O Open when powered up
C Closed with no power
X Verified
- Does not apply

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Automatic Temperature Control Functional Test Samples
Air Handling Units

Unoccupied Mode

(Chilled water valve reference to be substituted with DX cooling status as appropriate)

1. Place the control system in the unoccupied mode by changing the schedule.
2. Verify that all controlled points listed are off, OSA dampers are closed.
3. Verify by physical inspection (PI) that all controlled points are off and dampers are in the correct position.

AH/BCU/VAVR:					
Supply fan command displayed OFF					
Supply fan status displayed OFF					
Supply fan, PI OFF					
Heating valve command displayed OPEN					
Cooling valve command displayed CLOSED					
OSA damper position displayed CLOSED					
OSA damper position, PI CLOSE					
Return air damper position displayed OPEN					
Return air damper position, PI OPEN					
Relief damper position displayed CLOSED					
Relief damper position, PI CLOSED					
Supply fan command displayed OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Unoccupied Limits

1. Place the system in the unoccupied mode and verify all AHU and hydronic heating/cooling systems are off and heating, economizer and cooling are not locked out.
2. Simulate a zone temperature below the unoccupied low limit.
3. Verify unit comes on in full recirculation, boilers and pumps start and heating system modulates to control zone temperature.
4. Verify unit stops when zone is satisfied.
5. Simulate a zone temperature above the unoccupied high limit
6. Verify unit comes on in cooling, chilled water system starts and the system modulates to control zone temperature.
7. Verify unit stops when zone is satisfied.

AH/BCU/VAVR:					
Pre-Test:					
Unoccupied low limit					
Unoccupied high limit					
Zone temperature					
AHUs Off, Boilers Off, Chiller Off, Pumps Off					
Test:					
Unoccupied low limit changed to					
Supply fan command displayed					
Supply fan status displayed					
Heating valve command displayed					
Cooling valve command displayed					
OSA damper position displayed					
Return air damper position displayed					
Return air temperature					
Mixed air temperature					
Outside air temperature					
Relief damper position displayed					
DAT					
System off when satisfied					
Unoccupied high limit changed to					
Supply fan command displayed					
Supply fan status displayed					
Cooling valve command displayed					
Heating valve command displayed					
OSA damper position displayed					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
Relief damper position displayed					
DAT					
System off when satisfied					

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☐ Setpoints returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Unoccupied Pushbutton Override – AHU

1. Place the system in the unoccupied mode and verify all AHU and hydronic heating/cooling systems are off.
2. Set the override period to a minimum value.
3. Simulate a call for heating or cooling as required, test a minimum of two each for heating and cooling.
4. One at a time, press the override button for each space.
5. Verify the AHU goes into the occupied mode and boiler or chiller system is enabled as appropriate.
6. Verify unit stops and boiler/chiller shuts down at end of time period.

AH/BCU/VAVR:					
Pre-Test:					
Override run time					
Zone temperature					
Zone setpoint					
AHU Off, Boilers Off, Chiller Off, Pumps Off					
Test:					
Override run time adjusted to					
Zone temperature setpoint adjusted to					
Heat Test or Cool Test					
Hydronic circulation pump command ON					
Hydronic circulation pump status ON					
Boiler or Chiller Command ON					
Boiler or Chiller status displayed ON					
Supply fan command displayed ON					
Supply fan status displayed ON					
OSA damper position displayed Min					
Return air damper position displayed (100-OSA%)					
Heating/cooling valve command OPEN					
Outside air temperature					
Mixed air temperature					
Discharge air temperature					
System return to unoccupied at end of override period					

☐ Set points returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Coil Valve Leak Test

1. Verify occupied set point is equal to space temperature in each space to eliminate a demand for heat or cool.
2. Place the control system in the occupied mode.
3. Verify heating and chilled water systems are enabled and circulating water. As required, override reset to produce water temperatures at the high/low end of the reset schedule. Record temperatures
4. Verify AHU is operational.
5. Verify that the heating and cooling valves are indicated as closed by the BAS. Record the AHU supply air temperature and the mixed air temperature for each unit, verify by temperature change that the valves are closed.

Heating loop supply temperature start of test _____ °F
Heating loop return temperature start of test _____ °F

Unit No.	Htg Valve	AH/BCU /VAVR SAT	AH/BCU /VAVR MAT	ΔT °F

☐ Set points returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Thermostat Calibration and Point to Point Test.

1. At each thermostat location, press override push button (or raise/lower setpoint).
2. Verify that BAS indicates correct zone in override.
3. Measure room air temperature and record actual and BAS indicated temperatures.

Unit No.	Override	Room Temp	BAS Temp	Unit No.	Override	Room Temp	BAS Temp

☐ Set points returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Occupied Mode Tests

1. Place the system in the occupied mode by changing the schedule.
2. Verify by physical inspection that the supply fan starts, the air dampers modulate to normal position (minimum air or higher), heating and cooling valves are positioned to control to current setpoint, relief dampers open and other parameters are normal.
3. Verify BAS displays the correct status for the fan coil units.

AH/BCU/VAVR:					
Space temperature					
Space temperature set point					
Supply fan command displayed					
Supply fan status displayed					
Supply fan, PI					
Heating valve command displayed					
Cooling valve command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
Relief damper position displayed					
Relief damper position, PI					
DAT					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Zone Control - Cooling

1. Verify outside air is below economizer lockout temperature.
2. Lower the zone setpoint slightly below the current zone temperature.
3. Verify outside air dampers open for economizer cooling and that chilled water valve remains closed.
4. With an increased call for cooling, verify cooling valve opens to control supply air setpoint.
5. Mixed Air Low Limit: Simulate a mixed air temperature below the mixed air low limit setpoint and verify mixed air low limit overrides the economizer control by closing the outside air damper. Release low limit when done.
6. Economizer Lockout1: Simulate an OSA temperature above the return air temperature and verify OSA dampers modulate to minimum position. Release when done.
7. Economizer Lockout2: Simulate an OSA temperature above the Economizer Lockout Setpoint and verify OSA dampers modulate to minimum position.
8. Raise setpoint to eliminate a call for cooling.
9. Cooling with economizer lockout: With economizer locked out. Create a demand for cooler air. Verify cooling valve opens immediately.

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Cooling Control:

AH/BCU/VAVR:					
Pre-Test:					
Economizer minimum setpoint					
Zone temperature					
Zone setpoint					
Discharge air setpoint					
Discharge air temperature					
Outside air temperature					
Economizer minimum setpoint					
Economizer lockout setpoint					
Economizer damper position					
OAT					
RAT					
MAT					
DAT					
Mixed air low limit setpoint					
Test:					
Zone setpoint lowered to					
Discharge air setpoint reset to					
Heating valve command displayed					
Cooling valve command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position displayed					
Return air damper position, PI					
Relief air damper position displayed					
Relief air damper position, PI					
Return air temperature					
Mixed air temperature					
Discharge air temperature after about 3 minutes					
Economizer is first stage of cooling					
Zone setpoint lowered to					
Discharge air setpoint reset to					
Cooling valve command displayed					
OSA damper position displayed					
Return air damper position displayed					
Relief air damper position displayed					
Return air temperature					
Mixed air temperature					
Discharge air temperature after about 3 minutes					
Cooling coil is second stage of cooling					

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AH/BCU/VAVR:					
Mixed Air Low Limit					
Mixed air low limit setpoint changed to					
Outside air dampers close to control to MLL					
Economizer Lockout					
Dampers to minimum position on economizer lockout based on return air					
Dampers to minimum position on economizer lockout based on outside air					
Cooling control during economizer lockout:					
Zone setpoint lowered to					
Cooling valve command displayed					
OSA damper position displayed					
Supply air temperature after about 3 minutes.					
RAT					
MAT					
Cooling coil is first stage of cooling					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Zone Control - Heating

1. While system is still in cooling, simulate a zone temperature below the zone temperature setpoint.
2. Verify economizer is at minimum.
3. Verify discharge air temperature setpoint is reset higher in response to heating demand.
4. Verify heating valve opens to control to set point.

Heating Control:

AH/BCU/VAVR:					
Pre-Test:					
Economizer minimum setpoint					
Zone temperature					
Zone setpoint					
Discharge air setpoint					
Discharge air temperature					
Test:					
Setpoint raised to					
Discharge air setpoint reset to					
Economizer at minimum					
Heating valve command displayed					
Cooling valve command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position displayed					
Return air damper position, PI					
Relief air damper position displayed					
Relief air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
Discharge air temperature after about 3 minutes					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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AHU Hard Wire Shutdowns:

1. Mixed Air Low Temperature: Trip freeze stat and verify fan shuts down and dampers close.

AH:					
Shutdown on freeze					
Reset OK					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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AHU Occupancy Sensor Test

1. Verify system is in the occupied mode.
2. Vacate all rooms and let occupancy timers time out.
3. Verify each AHU damper set goes to full recirculation (this will have to be by BAS only as the dampers are above the ceiling in each room).
4. One at a time, enter each room and verify AHU returns to normal occupancy mode with dampers at minimum or greater depending on heating/cooling demand.

AH/BCU/VAVR-						
"Unoccupied" State:						
Dampers in full recirculation						
"Occupied" State:						
Dampers at ≥ Minimum						
AH/BCU?VAVR-						
"Unoccupied" State:						
Dampers in full recirculation						
"Occupied" State:						
Dampers at ≥ Minimum						

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Exhaust Fans

BAS Controlled Exhaust Fan Test (with Fan Proof)

1. Place the control system in the unoccupied mode.
2. Verify all exhaust fans under BAS control are commanded off, display an off status and are off by physical inspection (PI).
3. Place the system in the occupied mode.
4. Verify all exhaust fans under BAS control are commanded on, display an on status and are on by physical inspection (PI).
5. Turn off the exhaust fan at the disconnect and verify fan failure alarm is generated.
6. Turn power to fan back on and verify alarm clears.

EF/RF-	1	2	3	4	5
Unoccupied Mode:					
Exhaust fan command displayed OFF					
Exhaust fan status displayed OFF					
Exhaust fan, PI OFF					
Occupied Mode:					
Exhaust fan command displayed ON					
Exhaust fan status displayed ON					
Exhaust fan, PI ON					
Exhaust fan failure alarm received					
Exhaust fan failure alarm cleared					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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BAS Controlled Exhaust Fan Test (without Fan Proof)

1. Place the control system in the unoccupied mode.
2. Verify all exhaust fans under BAS control display an off status and are off by physical inspection (PI).
3. Place the system in the occupied mode.
4. Verify all exhaust fans under BAS control display an on status and are on by physical inspection (PI).

EF/RF-	1	2	3	4	5	6	7	8
Unoccupied Mode:								
Exhaust fan command displayed OFF								
Exhaust fan, PI OFF								
Occupied Mode:								
Exhaust fan command displayed ON								
Exhaust fan, PI ON								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Manual Control Exhaust Fan Test

1. Turn exhaust fan on at local switch and verify fan starts.
2. Turn exhaust fan off at local switch and verify fan stops

EF/RF-	1	2	3	4	5	6	7	8
Fan Starts								
Fan Stops								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Manual Timer Control Exhaust Fan Test

1. Verify timer is at zero and exhaust fan is off.
2. Turn timer to minimum increment and record timer setting and time of day.
3. Verify fan comes on.
4. Monitor timer/fan until shut off and record time. Verify run time matches timer.

EF/RF-	1	2	3	4	5	6	7	8
Timer at zero, fan off								
Timer set to								
Time of day								
Fan on								
Time of day fan off								
Fan run time								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Thermostatically Controlled Exhaust Fan Tests (BAS)

1. Lower thermostat setpoint to below room temperature or simulate a space temperature higher than setpoint. Verify fan starts when space temperature is above setpoint and BAS is correct.
2. Raise thermostat setpoint above room temperature or simulate a space temperature lower than setpoint. Verify fan stops when space temperature is below setpoint and BAS is correct.

EF/RF-	1	2	3	4	5
Space temperature start of test					
Setpoint start of test					
Setpoint [ ] or Simulated Space [ ] temp					
Exhaust fan command/status displayed ON					
Exhaust fan, PI ON					
Setpoint [ ] or Simulated Space [ ] temp					
Exhaust fan command/status displayed OFF					
Exhaust fan, PI OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Thermostatically Controlled Exhaust Fan Tests (Line Voltage)

1. Lower thermostat setpoint to below room temperature or simulate a space temperature higher than setpoint. Verify fan starts when space temperature is above setpoint
2. Raise thermostat setpoint above room temperature or simulate a space temperature lower than setpoint. Verify fan stops when space temperature is below setpoint.

EF/RF-	1	2	3	4	5
Space temperature start of test					
Setpoint start of test					
Setpoint [ ] or Simulated Space [ ] temp					
Exhaust fan ON					
Setpoint [ ] or Simulated Space [ ] temp					
Exhaust fan OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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VAV Tests

Pre-Test: Unit:	VAVR-1	VAVR-2	VAVR-3	VAVR-4	VAVR-5	VAVR-6	VAVR-7	VAVR-8	VAVR-9	VAVR-10
Design Heating CFM										
Programmed CFM Setpoint										
Design Delta T										
Zone Temperature										
Zone Temp Htg Setpoint										
Test:										
Setpoint [ ] or ZT Override [ ]										
Displayed CFM Setpoint										
Displayed Actual CFM										
Damper Position										
Valve or Heating %										
VAV discharge temperature										
AHU SAT										
Delta T Heating Element										
VAV DAT as % of design DAT										
Displayed CFM as % of S.P.										
Test OK or list Issue Number:										

Cooling Pre-Test: Unit:	VAVR-1	VAVR-2	VAVR-3	VAVR-4	VAVR-5	VAVR-6	VAVR-7	VAVR-8	VAVR-9	VAVR-10
Design Cooling CFM										
Programmed CFM Setpoint										
Zone Temperature										
Zone Temp Clg Setpoint										
Test:										
Setpoint [ ] or ZT Override [ ]										
Displayed CFM Setpoint										
Displayed Actual CFM										
Damper Position										
VAV discharge temperature										
AHU SAT										
Delta from AHU SAT										

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Displayed CFM as % of S.P.										

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Pumps

Unoccupied Mode:

1. Place the control system in the unoccupied mode.
2. Verify all pumps under BAS control display an OFF command and status.
3. Verify all pumps under BAS control are off by direct observation.

Unit No.	Command OFF	Status OFF	Unit OFF
HWP-1			
HWP-2			
CHWP-1			
CHWP-2			

Occupied Mode:

1. Place the control system in the unoccupied mode.
2. Verify all pumps under BAS control display an ON command and status.
3. Verify all pumps under BAS control are off by direct observation.

Unit No.	Command OFF	Status OFF	Unit OFF
HWP-1			
HWP-2			
CHWP-1			
CHWP-2			

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Pump Lead/Lag and Failure/Alarm

1. Conduct test with lead pump running
2. Record lead and lag pump status.
3. At the lead pump motor control center, turn the switch from Auto to Off.
4. Verify lag pump starts.
5. Turn lead pump back on, this should just require switching the MCC to Auto but also may require software reset.
6. Repeat test by disconnecting power to pump.
7. Trip the lead/lag sequence and verify the lag pump becomes the lead.
8. Repeat 1-5 for the new lead pump.

	HOA	AC Fail		HOA	AC Fail
Lead Pump	P-1	P-1		P-2	P-2
Lead Status					
Lag Pump	P-2	P-2		P-1	P-1
Lag Status					
Lag Start on Lead Fail?					
Pump Failure Alarm Reported?					
Lead/Lag Switched?					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Hydronic loop pressure control

1. Verify pumping system is operational.
2. Record initial pressure setpoints and system readings. As option, also set up trend log for pressure, setpoint and VFD feed back.
3. Raise system pressure setpoint and allow system to stabilize.
4. Verify variable speed pumping system controls to new setpoint.
5. Lower system pressure setpoint below original setpoint and verify variable speed pumping system controls to new setpoint.
6. Repeat for all pumps.

Lead Pump:	P-1	P-2
Start of test:		
Differential pressure setpoint		
Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
Test:		
Differential pressure setpoint changed to		
Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
System controls		
Differential pressure setpoint changed to		
Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
System controls		
Differential pressure setpoint returned to original value		
Tests are complete and performance is acceptable		

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

END OF SECTION 230800

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SECTION 230900 - MECHANICAL CONTROL SYSTEMS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-23 General Mechanical Requirements sections apply to work of this section.

1.2 DESCRIPTION OF WORK:

A. Extent of control systems work required by this section is indicated on drawings and schedules, and by requirements of this section.

1. See following sections for types of Control Systems included as a part of this section. See electrical, automation, etc.

2. Control sequences are specified in this section under: "Sequence of Operation".

B. Refer to other Division-15 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems.

C. Refer to Division-26 sections for the following work.

1. Power supply wiring from power source to power connection on controls and/or unit control panels. Includes starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

2. Interlock wiring between electrically-operated equipment units; and between equipment and field-installed control devices.

a. Interlock wiring specified as factory-installed is work of this section.

D. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:

1. Control wiring between field-installed equipment, controls, indicating devices, and unit control panels. All control wiring shall be in conduit.

2. 120 volt service required by control systems.

E. Participate in "System Commissioning, Testing and Balancing".

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electric control equipment, of type and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years. This project shall be bid using CSI TAC/INET.

B. Installer's Qualifications: Firms and workmen specializing and experienced in electric control system installation for not less than 5 years. Selected from Utah Controls shall be the contractor. Installer shall be under the direction of the controls manufacturer.

C. Codes and Standards:

1. Electrical Standards: Provide electrical products which have been tested, listed and labeled by UL and comply with NEMA standards.

2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

4. Comply with NEPA 70, "National Electric Code" for all electrical installation.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.

B. Shop Drawings: Submit shop drawings for each control system, containing the following information:

1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.

2. Label each control device with setting or adjustable range of control.

3. Indicate all required electrical wiring. Clearly differentiate between portions of work that are factory-installed and portions to be field-installed. Note contract responsibility to provide complete system regardless of delegation. Completely interface with and show existing installation in the Administration building.

4. Provide details of faces of control panels, including controls, instruments, and labeling.

5. Include written description of sequence of operation. Confirm correct function of proposed sequences.

C. Samples: Submit sample of each type of proposed thermostat cover.

D. Maintenance Data: Submit maintenance instructions and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Section 230100.

1.5 DELIVERY, STORAGE, AND HANDLING: Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

1.6 INSTRUCTION OF OWNER'S PERSONNEL: (See Section 230000)

A. Purpose is to provide a transition of the systems from the Contractor to the Owner, leaving the Owner's personnel familiar with and well qualified to operate and maintain the systems.

B. Instruction to cover purpose and function of each system and its components, to show proper operating technique, to show proper maintenance technique.

C. Prepare an outline of information to be conveyed, list materials available for reference. Submit to Architect along with a proposed schedule of instruction. Schedule to allow individual time for each trade and each system.

D. Convey information in formal classroom session. Teachers to include qualified contractor personnel and sales representatives for each major piece of equipment. Go from the classroom to the actual location to graphically illustrate concepts discussed.

E. Each and every session shall be video taped by the Contractor and given to the Owner.

1.7 WARRANTIES:

A. As part of the overall project warranty, furnish individual manufacturer warranties for each piece of equipment for a period of not less than one year from date of Owner's beneficial use (substantial completion).

B. Warrant the overall assembly of equipment, materials and labor comprising these systems.

1.8 CLEANING AND LUBRICATION: All instruments, control panel and control piping shall be thoroughly cleaned before final acceptance. Provide lubrication for all furnished equipment.

1.9 TESTING AND ADJUSTING OF SYSTEM:

A. During the system commissioning, testing and balancing of the various building systems, have a controls representative(s) present and available to interpret and adjust controls as needed. Demonstrate and report the integrity and accuracy of each function and control point.

B. At the termination of the testing period, the Controls representative shall spend one working day instructing the Owner's operating personnel in the control system operation, and one working day checking each system for day-night and manual override with the Owner's operating personnel on each air system. A complete operating booklet shall be provided and used during the training period. Schedule this training with the Owner and Mechanical Contractor.

Since system performance is partly a function of climatic conditions, the Controls contractor shall be available during the changing seasons of the warranty period to make further adjustments and modifications if required. A final complete check of all systems shall be made at the conclusion of the one year warranty period.

PART II - PRODUCTS

2.1 CONTROL CABINETS: Furnish stamped steel with hinged door and locking latch control cabinets to protect and conceal all control devices. Arrange components neatly to provide adequate maintenance opportunity and proper device function. Label all components, numerically code all piping and wiring. Terminate all wiring at terminal blocks. Provide engraved plastic labels for all panel face devices.

2.2 DAMPERS:

A. Automatic dampers that are not in factory air handling units such as relief dampers and ventilation dampers shall be provided in this section.

B. In supplying dampers, instruct the sheet metal (Section 233100) workers in the proper installation of the dampers. Ductwork shall be reinforced and the damper properly supported without strain.

C. Protect all dampers mounted in a duct system which requires special treatment such as acid resistant coating as specified for that system.

D. Provide damper operators with diaphragms or motors of proper size, so that the motors will operate against the static pressure of the systems. Provide each damper motor with a bracket for attaching to ductwork, building structure or equivalent. Damper motors in plenums shall be mounted on damper frames. Do not install motors in ducts. Modulating motors where indicated shall be provided with integral stops for both minimum and maximum stop.

E. Control dampers for outside air and other dampers exposed to weather temperatures in built-up systems. Low leakage type with spring loaded side seals, inflatable butyl or neoprene fabric edge seals, bronze or teflon bearings, reinforced galvanized steel blades. Parallel action. Air leakage not to exceed 10 CFM per square foot at 4" upstream static pressure.

Honeywell "Moduflow" D-634.
Johnson "Proportion-Aire" D-1200/D-1300.
Ruskin CD50
Greenheck VCD-43

2.3 CONTROL VALVES:

A. Furnish automatic control valves required by the project. Design valves to pass the quantities of fluid at the pressure drop scheduled on the drawings.

B. Mount all control valves with stems in the up-vertical position. Valves shall have stainless steel trim, renewable seats.

C. Furnish valve operators with adequate capacity to operate the valve smoothly through the operating range. Provide oversized motors or operator if needed. Voltage ranges or pressure ranges shall be adjustable, the equivalent of pilot positioning for electric functions.

PART III - CONTROL SEQUENCES

3.1 GENERAL:

A. Provide control systems to manage and manipulate mechanical equipment in a functional and energy conserving way.

B. Provide control panels in the central fan rooms, boiler room; with terminal block connections for interface of fans, pumps, etc.

3.2 CENTRAL CONTROL AND MONITORING SYSTEM:

A. Central Control Units shall provide for overall control and monitoring of the Building System.

B. DDC panels shall also provide programmable timeclock functions, optimum start, and signals to ATC panels and report space temperature and condition of air handling system functions.

C. Locate DDC panels in mechanical room as shown on the drawings or as directed in the field.

3.3 VARIABLE VOLUME SYSTEM:

A. SUPPLY FAN STATIC PRESSURE CONTROL SEQUENCE (AH-1):

1. The supply VFD's start via the DDC system.

2. The speed of the supply fan through its respective VFD will be controlled to maintain the far end duct static pressure setpoint at approximately 0.5" w.c. Duct sensor will provide signals to the DDC duct pressure controller. The DDC controller will provide a 4-20 ma input signal to the variable speed drive for the supply fan.

3. The variable speed drive will be interlocked to the safeties relay to provide shutdown upon building fire alarm, smoke detection, freezing conditions and high duct pressure conditions. The variable speed drive will interlock with the relief fan. The fans are activated through the central control panel.

4. The outside air dampers and minimum outside air dampers will be interlocked with their respective fan to close all the dampers when the fan is off. The return air damper shall open when the fan is off.

5. Chilled water valve shall close when fan is off.

6. The fan speed shall also be able to be set and adjusted manually.

B. TEMPERATURE/ECONOMIZER CONTROL SEQUENCE (AH-1):

1. The discharge air shall be controlled by modulating the chilled water control valve in sequence with the outside air/return air dampers. If the outside air temperature is such that cooling can occur, the outside air and return air dampers shall modulate to provide a mixed air temperature of 55^{o}F. Once the outside air temperature exceeds 80^{o}F (adjustable), the outside air damper shall close to its minimum position.

2. If the discharge air temperature setpoint cannot be met by the use of outside air, the chilled water valve shall modulate to provide chilled water to the cooling coils. The chilled water return temperature will be sensed with input into the controller to ensure that the chilled water is being fully utilized.

3. The chilled water valve shall close when the fan is off.

4. If the discharge air temperature drops below 55^{o} due to minimum outside air requirements, the heating coil shall modulate.

C. MINIMUM OUTSIDE AIR SYSTEM: (AH-1).

1. The minimum outside air damper opens to its minimum position whenever the fan runs. The minimum outside air position shall be controlled by measurement of CO_2 by a sensor mounted in the RA path to provide up to the minimum outside air scheduled.

2. In the unoccupied and night setback mode, the minimum outside air damper is closed and the main outside air supply for the fan is shut off.

3. Low limit controller prevents the mixed air temperature from dropping below 36^{o}F.

D. BUILDING STATIC PRESSURE CONTROL SEQUENCE: Relief Air Fans, for system AH-1.

1. The relief fans shall be controlled by a variable frequency drives.

2. In auto, the relief fans can run if its respective supply fan is on. In hand or bypass, the relief fans will run.

3. Building differential pressure sensors for the system, located as shown on the drawings, send a signal to the central automation system. Each system shall be set to maintain a 0.03" (adjustable) positive building pressure relative to the outside.

The central panel selects the lower of the building pressure sensor signals to control the relief fan and dampers. The controller in turn will establish the speed of the relief fan through its frequency drive and modulate the relief damper.

E. ROOM/SPACE TEMPERATURE CONTROL SEQUENCES:

1. VAV COOLING WITH TERMINAL REHEAT: Each room/space VAV box with reheat coil shall be controlled by a DDC controller fed through the central control panel, including a VAV box inlet flow sensor and outlet temperature sensor. This will allow for remote monitoring and remote changing of unit parameters.

When the room temperature is above the setpoint of the unit controller as sensed by the space sensor, the VAV box will be open, the heating coil valve will be closed.

As the room temperature drops to setpoint, the VAV box modulates to its minimum. This minimum shall be fully automatically adjustable and set as called for on the Drawings.

When any room drops below setpoint, the VAV shall modulate open the heating water valve and modulate the box damper up to heating maximum cfm to maintain temperature setpoints.

3.4 SINGLE ZONE UNIT:

A. SUPPLY FAN STATIC PRESSURE CONTROL SEQUENCE:

1. Typical for Systems AHU-2.

2. The supply from starts via the DDC system.

3. The fan shall be interlocked to the safeties relay to provide shutdown upon building fire alarm, smoke detection and freezing conditions. The fan is activated through the central control panel.

4. The outside air dampers and minimum outside air dampers will be interlocked with their respective fan to close the dampers when the fan is off. The return air damper shall open when the fan is off.

5. Chilled water valve shall close when fan is off.

B. TEMPERATURE CONTROL SEQUENCE – SINGLE ZONE:

1. Typical for System AH-2.

2. The discharge air shall be controlled by modulating the chilled water control valve. The chilled water return temperature will be sensed with input into the controller to ensure that the chilled water is being fully utilized. The chilled water valve shall close when the fan is off.

3. On a call for heating, the heating coil vavle shall modulate.

C. MINIMUM OUTSIDE AIR SYSTEM: (AHU-2)

1. The minimum outside air damper opens to its minimum position of 5% whenever the fan runs. It modulates further open on demand of CO2 sensor/transducers and volatile organic compound sensor/transducers in return air. It will open to a maximum of 2,500 cfm, unless in an economizer mode.

2. In the unoccupied and night setback mode, the minimum outside air damper is closed and the main outside air supply for the fan is shut off.

3. Low limit controller prevents the mixed air temperature from dropping below 36^{o}F.

3.5 BOILER ROOM VENTILATION: (VF-1) Upon a rise in temperature, a two stage wall thermostat shall start the vent fan to run on low speed and open its intake dampers. Interlock the vent fan with the intake dampers so that the dampers open when the fan operates. On a continued rise in temperature the vent fan will operate at high speed. The reverse will happen on a drop in temperature.

3.6 EXHAUST FANS: Each fan shall cycle from a start/stop signal from the Central Control System through the DDC panel. Interlock the exhaust damper so that the dampers open when the fan operates.

3.7 UNIT HEATERS: With the heating water circulating, fan cycles from the DDC system from signal from room sensor to maintain space temperature.

3.8 DOMESTIC WATER HEATERS WH-1: (Gas Fired) forced draft (Self-contained controls)

3.9 DOMESTIC HOT WATER RECIRCULATING PUMPS: RCP-1

A. Controlled from the on-off switch in the ATC panel in on position, the start/stop signal

comes from the DDC system.

B. Recirculating pumps stop with night set back signal from DDC.

3.10 BUILDING HEAT CONTROL B-1, B-2, HWP-1, HWP-2:

A. General: On a call for heat by a VCV box or BCU and the outside air temperature is below 50^{o}F, a start signal is sent to the heating water pumps and boiler control panel.

B. (Administration Building) Heating Water Circulating Pumps HWP-1, HWP-2: Based on a signal from the DDC system, one of the two heating water circulating pumps start. Only one needs to run at a time, the two pumps alternate operation on a scheduled basis. A differential pressure signal indicates through the DDC system which pump is running. If one pump fails the other one will start and an alarm will be issued. Each VFD will vary the speed of its respective pump to provide the flow necessary to feed the coils calling for heating.

C. (Billeting Building) Heating Water Circulating Pumps HWP-1, HWP-2: Based on a signal from the DDC system, one of the two heating water circulating pumps start. Only one needs to run at a time, the two pumps alternate operation on a scheduled basis. A differential pressure signal indicates through the DDC system which pump is running. If one pump fails the other one will start and an alarm will be issued.

D. Boilers B-1, B-2:

1. Upon proof of flow from the boiler circulating pump and the flow switch and start signal from the DDC system, the boiler system will be placed in the enabled mode.

2. There are two boilers. The boilers operate via a boiler control panel and system furnished with the boilers.

3.11 CHILLED WATER SYSTEM SEQUENCE:

A. General:

1. In the occupied mode and based on any call for cooling from a VAV box or BCU and the outside air temperatures above 50^{o}F, a start signal is sent to the chilled water pumps and chiller control circuit.

B. Chiller Circulating Pumps CWP-1 & 2:

1. Based on a signal from the DDC system. One of the two chilled circulating pumps start. Only one need run at a time. The two pumps alternate operation on a scheduled basis. A differential pressure signal indicates through the DDC system which pump is running. If one pump fails the other one will start and an alarm will be issued.

C. Chiller C-1:

1. Upon proof of flow from the chiller circulating pump and the flow switch and a start signal from the DDC system, the chiller will be placed in Ready Mode.

2. The chiller will operate on the chilled water return temperature through factory controls to maintain chilled water temperature.

3. On shut down the chiller circulating pump will run for 15 minutes (adjustable) after the chiller shuts down. Then the pump will shut down.

3.12 GLYCOL MAKE-UP UNIT GM-1:

A. The glycol make-up unit cycles to maintain the chilled water system pressures.

3.13 MAKE-UP AIR/ROOFTOP UNIT (MAU-1):

A. The make-up air unit is controlled through the DDC system. Blower runs continuously during occupied mode. The exhaust fans operate when the fan is on.

B. The heating system is enabled through the DDC system. On a call for heat as sensed by the duct sensor, the heating system is enabled; the unit heating system is then controlled through the package controls furnished with the unit. Heating temperature is set via a remote temperature selector furnished with the unit.

C. In the setback mode, if any of the blower coil untis operate, the fan is cycled on, the outside air damper is open and the gas fired heat modulates to maintain space temperature.

D. Whenever the supply fan is off, the outside air damper is closed.

E. All systems shut down through building fire alarm.

F. Reference Section 15855 for factory controls. Furnish with the unit. Fully coordinate building DDC system with unit controls.

3.14 BLOWER COIL UNITS:

A. The building DDC system has the unit off during unoccupied hours. Should the unoccupied temperature drop to 65^{o}, the space sensor activates the fan and modulates the HW coil until the temperature rises to 65^{o}.

B. In the occupied mode, the fan runs continuously, the space sensors modulate the heating water valves, and chilled water valve in sequence to maintain setpoint. A discharge air sensor limit prevents their respective HW valve, CHW valve from operating via a DDC controller when the sensed temperature is above or below setpoint on the controller.

C. The chilled water valve and heating water valve close when fan is off.

D. The offices will each have a remote sensor with a $\pm 4^{o}$ override dial.

E. The dormitory rooms and offices will also have a remote temperature override with a $\pm 4^{o}$ offset. This will allow the occupants to offset the DDC system setpoint by turning the override dial.

3.15 CABINET HEATERS:

A. Upon a drop in temperature, a DDC wall sensor through the DDC controller opens the control valve. The aquastat mounted on the HW piping senses change in temperature, the fan starts and runs on one of its manually selected speeds.

3.16 AUTOMATED FUNCTIONAL TESTING SYSTEM - SEQUENCE OF OPERATIONS

A. This section includes the addition of graphical interface screens and associated programming to create an Automated Functional Testing System (AFTS) for the selected controlled systems indicated. The purpose of the AFTS is to provide the building operator with a diagnostic tool that will assist in the evaluation of the most common, non-obvious, system failures in support of the continuous commissioning of the HVAC systems. These failures involve the heating/cooling valves, mixing dampers, VAV flow sensors sand VAV air valves. Failure of these components reduces the energy efficiency and occupant comfort of the systems.

B. The submittal data referenced in paragraph 1.4 shall include proposed layouts for the AFTS as well as any proposed modifications to the test sequence. Exhibits 1 – 4 at the end of this section give proposed graphical screen layouts.

C. System Graphics Screens

1. The graphic screens shall be laid out on a single screen when possible. For systems with a large number of units (requiring more rows than will fit on one screen easily) multiple screens shall be used. For VAV testing screens, there must be a minimum of two screens per group of VAV terminal units served by a common air handler. This is necessary because some terminal unit testing must be split in half (as a minimum).
2. When considering how many units to place on one screen, system response time and space limitations shall be considered by the contractor such that the screen is easily readable and updates with all data in less than 10 seconds. Multiple screens shall share the same common header information.
3. The graphics screens shall contain navigation buttons to and from the test screen. When multiple pages are used, each screen shall include navigation buttons to go to/from companion screens.
4. Blower Coil Graphic Screens
    a. Screen Title: Blower Coil Automated Functional Tests
    b. The following test initiation buttons or check boxes shall be included in the screen header. These shall not be able to be selected unless no test is currently running:
        i. Test BC1 Heating Valve Leakage
        ii. Test BC2 Heating Capacity
        iii. Test BC3 Chilled Valve Leakage
        iv. Test BC4 Cooling Capacity Test
    c. Automatic Disable (user adjustable, set at 15 minutes)
    d. Outside air temperature
    e. Heating Valve Leakage Tolerance set point (user adjustable, set at 5 deg F)
    f. Chilled Valve Leakage Tolerance set point (user adjustable, set at 5 deg F)
    g. Heating Capacity Tolerance (user adjustable, set at 20%)
    h. Cooling Capacity Tolerance (user adjustable, set at 20%)
    i. Minimum Required HWS Temperature Lockout (user adjustable, set at 160 deg F)
    j. Maximum Allowed CWS Temperature Lockout Set Point (user adjustable, set at 48 deg F)
    k. Hot water supply and return temperatures
    l. Chilled water supply and return temperatures
    m. MAU supply air temperature
    n. For each Blower Coil, in a single row identified by unit number, display each of the following with a column header for each value:
        i. Heating coil design differential temperature (user adjustable, set at final design value)

ii. Cooling coil design differential temperature (user adjustable, set at final design value)

iii. Return air temperature

iv. Mixed air temperature

v. Supply air temperature

vi. Calculated difference between supply and mixed air temperatures SAT-MAT (absolute value)

vii. Pass/Fail condition for Test BC1 to BC4.

5. VAV Terminal Unit Graphic Screens

a. Screen Title: VAV Terminal Unit Automated Functional Tests

b. There shall a minimum of two screens for the VAV terminal units serving a given AHU to allow for testing half of the units at a time.

c. VAV units shall be listed in an orderly fashion, by unit number, by floor, etc. Only VAVs served by a common AHU shall be on any given page.

d. The following test initiation buttons or check boxes shall be included in the screen header. These shall not be able to be selected unless no test is currently running:

i. Test V1 Flow Zero

ii. Test V2 Damper Leakage

iii. Test V3 Cooling Flow & V4 Heat Valve Leakage

iv. Test V5 Heating Flow and V6 Heating Capacity

e. Automatic Disable (user adjustable, set at 15 minutes)

f. Zero Flow Tolerance set point (user adjustable, set at 10%)

g. Damper Leakage Tolerance set point (user adjustable, set at 15%)

h. Cooling Air Flow Tolerance set point (user adjustable, set at 10%)

i. Heating Valve Leakage Tolerance set point (user adjustable, set at 5 deg F)

j. Heating Air Flow Tolerance set point (user adjustable, set at 10%)

k. Heating Capacity Tolerance set point (user adjustable, set at 5 deg F)

l. AHU supply air temperature for unit serving VAVs

m. AHU duct static pressure for unit serving VAVs

n. Minimum Required HWS Temperature Lockout (user adjustable, set at 160 deg F)

o. Hot water supply and return temperatures

p. For each VAV, in a single row identified by unit number, display each of the following with a column header for each value.

i. Heating coil design differential temperature (user adjustable, set at final design value)

ii. Heating design air flow cfm (user adjustable, set at final design value)

iii. Cooling design air flow cfm (user adjustable, set at final design value)

iv. Air flow set point and Air flow measured value

v. VAV supply air temperature

vi. Calculated difference between AHU supply air temperature and VAV supply air temperature

vii. Test Pass/Fail condition for tests V1 to V6

6. Air Handling Units Graphics Screens

a. Screen Title: Air Handling Unit Automated Functional Tests

b. The following test initiation buttons or check boxes shall be included in the screen header. These shall not be able to be selected unless no test is currently running:

i. Test AH1 Heating Valve & AH2 Outside Air Damper Leakage

ii. Test AH3 Heating Capacity & AH4 Return Air Damper Leak

iii. Test AH5 Chilled Valve Leakage

iv. Test AH6 Cooling Capacity

c. Automatic Disable (user adjustable, set at 15 minutes)

d. Minimum Required HWS Temperature Lockout (user adjustable, set at 160 deg F)

e. Maximum Allowed CWS Temperature Lockout Set Point (user adjustable, set at 48 deg F)

f. Test outside air lockout set points, high and low (display only, not user adjustable, set at 55 and 40 deg F)

g. Outside air temperature

h. Hot water supply and return temperatures

i. Chilled water supply and return temperatures

j. Heating Valve Leakage Tolerance set point (user adjustable, set at 5 deg F)

k. Outside Air Damper Leakage Tolerance set point (user adjustable, set at 10% outside air)

l. Heating capacity Tolerance set point (user adjustable, set at 20%)

m. Return Air Damper Leakage Tolerance set point (user adjustable, set at 90% outside air)

n. Chilled Valve Leakage Tolerance set point (user adjustable, set at 5 deg F)

o. Cooling capacity Tolerance set point (user adjustable, set at 20%)

p. For each AHU, in a single row identified by unit number, display each of the following with a column header for each value:

i. Heating coil design differential temperature (user adjustable, set at final design value)

ii. Cooling coil design differential temperature (user adjustable, set at final design value)

iii. Return air temperature

iv. Mixed air temperature

v. Supply air temperature

vi. Calculated difference between supply and mixed air temperatures SAT-MAT (absolute value)

vii. Calculated percentage of outside air.

viii. Test Pass/Fail conditions for Tests AH1 to AH6

D. Automated Functional Test Sequence of Operations

1. Common Test Requirements

a. Under no conditions shall any equipment safeties be overridden by the AFTS sequence of operations.

b. All tests to be initiated by enabling a single point (button or check box)

c. No test shall be capable of being activated if another test is currently activated.

d. The pass/fail conditions for a given column on the screen are only to be displayed if that test is active.

e. Pass/fail conditions for a given test are only to be displayed after the specified delay from test initiation. Delays are specified in each test sequence.

f. Pass/fail conditions can be generated using the system alarm functions. If this is the case, the alarm shall be reported at the screen only and shall not be reported to the system alarm log or pop-up system to prevent “nuisance alarms”. The alarm (pass/fail) can be displayed as a color change, check box or other graphical means. Absence of an alarm shall indicate pass and alarm condition indication shall indicate fail.

g. When the test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication and clear alarm or pass/fail indication.

h. Regardless of user input, disable test after a period of time equal to the Automatic Disable value (user adjustable), clear Enable indication and clear alarm or pass/fail indication.

i. Tests are to be locked out under the conditions specified in the sequence. Provide a graphical means of indicating that the test is locked out and disable the test initiation button.

2. Formula Notation

a. Formulas stated in [ ]

b. ABS = Absolute Value

c. SAT = Supply Air Temperature

d. RAT = Return Air Temperature

e. MAT = Mixed Air Temperature

f. OAT = Outside Air Temperature

g. HDdT = Heating Design Differential Temperature

h. CDdT = Cooling Design Differential Temperature

i. HDAF = Heating Design Air Flow

j. CDAF = Cooling Design Air Flow

k. TT = Test Tolerance

l. dT = Differential Temperature

m. HWS = Hot Water Supply

n. CWS = Chilled Water Supply

3. Blower Coil Test BC1 Heating Valve Leakage

   a. Disable Test BC1 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point.

   b. Upon Test BC1 activation, enable all Blower Coils to operate in occupied mode, command all heating valves full closed and command the MAU to unoccupied.

   c. After a delay of 5 minutes, compare the calculated SAT-MAT to the leakage tolerance and if greater than the tolerance, indicate test failure, otherwise indicate test pass. [IF ABS(SAT-MAT) > TT, THEN FAIL] An excess rise in supply air over mixed air temperature is an indication of a leaking heating valve.

   d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

   e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

4. Blower Coil Test BC2 Heating Capacity

   a. Disable Test BC2 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point.

   b. Upon Test BC2 activation, enable all Blower Coils to operate in occupied mode, command all Blower Coil heating valves full open, chilled water valves full closed and MAU to unoccupied mode.

   c. After a delay of 5 minutes, compare the calculated SAT-MAT to the design heating capacity less the heating capacity tolerance and if SAT-MAT is less than the calculated criteria, indicate test failure, otherwise indicate test pass. [IF ABS(SAT-MAT) < (HDdT – (HDdT*TT) THEN FAIL]. A low rise in supply air over mixed air temperature is an indication of control valve problems or low water flow.

   d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

   e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

5. Blower Coil Test BC3 Chilled Water Valve Leak Test

   a. Disable Test BC3 if the chilled water loop temperature is above Maximum Allowed CWS Temperature Lockout Set Point.

   b. Upon Test BC3 activation, enable all Blower Coils to operate in occupied mode, command all chilled water valves full closed and command the Make Up Air unit into unoccupied.

   c. After a delay of 5 minutes, compare the calculated SAT-MAT to the leakage tolerance and if greater than the tolerance, indicate test failure, otherwise indicate test pass. [IF ABS(SAT-MAT) > TT THEN FAIL] An excess drop in supply air over mixed air temperature is an indication of a leaking cooling valve.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

6. Blower Coil Test BC4 Cooling Capacity

a. Disable Test BC4 if the chilled water loop temperature is above Maximum Allowed CWS Temperature Lockout Set Point.

b. Upon Test BC4 activation, enable all Blower Coils to operate in occupied mode, command all cooling valves full open, heating valves closed and command the Make Up Air unit into unoccupied.

c. After a delay of 5 minutes, compare the calculated SAT-MAT to the design cooling capacity less the cooling capacity tolerance and if SAT-MAT is less than the calculated criteria, indicate test failure, otherwise indicate test pass. [IF ABS(SAT-MAT < (CDdT-CDdt*TT) THEN FAIL]. A low drop in supply air under mixed air temperature is an indication of control valve problems or low water flow.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

7. VAV Test V1 – Flow Zero

a. Upon Test V1 activation, command the AHU serving the VAV terminal units for each screen group to the unoccupied mode.

b. Command all VAV terminal unit air valves shut.

c. After a delay of 3 minutes, compare the VAV measured air flow to the zero tolerance times the design cooling air flow and if greater than the tolerance, indicate test failure, otherwise indicate test pass [IF MAF > CDAF*TT THEN FAIL] . An excessively high non-zero value indicates a failed sensor or need for unit calibration.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 10 minutes (user adjustable), clear Enable indication.

8. VAV Test V2 – Air Valve Leakage

a. The VAV terminal units shall be tested in groups of no more than half the number of terminal units served by a single AHU. This is to prevent duct over-pressurization and to prevent low AHU supply volume which may produce false test failures.

b. Upon Test V2 activation, command the AHU serving the VAV terminal units for each screen group to the occupied mode.

c. Command all of the VAV terminal unit air valves associated with this screen shut. Important: Do not command all VAV terminal units associated with a single AHU shut at once as this may cause elevated duct pressure and damage equipment.

d. After a delay of 5 minutes, compare the VAV measured flow to the damper leakage tolerance and if the reading is greater than the criteria, indicate test failure, otherwise

indicate test pass [IF MAF > CDAF*TT THEN FAIL]. A low rise in supply air over mixed air temperature is an indication of control valve problems or low water flow.

e. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

f. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

9. VAV Test V3 Cooling Air Flow & Test V4 Heating Valve Leakage

a. The VAV terminal units shall be tested in groups of no more than half the number of terminal units served by a single AHU. This is to prevent duct over-pressurization and to prevent low AHU supply volume which may produce false test failures.

b. Disable Test V3&4 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point.

c. Upon Test V3&V4 activation, command the AHU serving the VAV terminal units for each screen group to the occupied mode.

d. Command all of the VAV terminal unit air valves associated with this screen into a full call for cooling. Important: Do not command all VAV terminal units associated with a single AHU open at once as this may cause low air flow resulting in false failed tests.

e. Wait a delay of 5 minutes. For Test V3 compare the measured air flow with the design cooling air flow (plus/minus tolerance value). If the measured air flow is greater than or less than the tolerance criteria then indicate a failure, otherwise indicate test pass [IF MAF < (CDAF-CDAF*TT) OR IF MAF > (CDAF+CDAF*TT) THEN FAIL]. For Test V4 compare the calculated VAV DT to the heating valve leak tolerance and if greater than the tolerance, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT) > TT, THEN FAIL]. A measured air flow below design flow indicates a bad flow sensor, broken air damper or low air serving VAV. A high VAV SAT relative to the AHU SAT indicates a leaking hot water valve.

f. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

g. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

10. VAV Test V5 – Heating Air Flow & Test V6 Heating Capacity

a. Disable Test V5&6 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point.

b. Upon Test V5&V6 activation, command the AHU serving the VAV terminal units for each screen group to the occupied mode.

c. Command all of the VAV terminal unit air valves associated with this screen into a full call for heating.

d. Wait a delay of 5 minutes. For Test V5 compare the measured air flow with the design heating air flow (less tolerance value). If the measured air flow is greater than or less than the tolerance criteria then indicate a failure, otherwise indicate test pass [IF MAF < (HDAF-HDAF*TT) OR IF MAF > (HDAF+HDAF*TT) THEN FAIL]. For Test V6 compare the calculated VAV DT to the design heating capacity less the tolerance and if less than the tolerance, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT) < (HDdT – HDdT*TT) THEN FAIL]. A measured air flow below design flow indicates a bad flow sensor, broken air damper or low air serving VAV. A low rise in VAV supply air over AHU supply air temperature is an indication of control valve problems or low water flow.

e. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

f. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

11. Air Handling Unit Test AH1 Heating Valve Leakage & Test AH2 Outside Damper Leakage

a. Disable Test AH1 & AH2 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point OR if Outside Air is below the Low Outside Air Temperature Lockout OR if outside air is above the High Outside Air Temperature Lockout set point.

b. Upon Test AH1 & AH2 activation, enable all Air Handling Units to operate in occupied mode, override mixing dampers to zero % outside air and command heating and cooling valves shut.

c. The formula for calculating the percent of outside air is [(MAT-RAT)/(OAT-RAT)].

d. Wait a delay of 5 minutes. For Test AH1 compare the calculated SAT-MAT to the leakage tolerance and if greater than the tolerance, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT) > TT, THEN FAIL]. An excess rise in supply air over mixed air temperature is an indication of a leaking heating valve. For Test AH2 compare the calculated percent of outside air to the outside air leakage tolerance and if grater than the tolerance, indicate test failure, otherwise indicate test pass. [IF %OSA > TT, THEN FAIL]. A high outside air percentage indicates leaking dampers, damper slipping on shaft or broken damper motor.

e. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

f. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

12. Air Handling Unit Test AH3 Heating Capacity & Test AH4 Return Damper Leakage

a. Disable Test AH3 & AH4 if boiler loop temperature is below Minimum Required HWS Temperature Lockout set point OR if Outside Air is below the Low Outside Air Temperature Lockout OR if outside air is above the High Outside Air Temperature Lockout set points.

b. Upon Test AH3 & AH4 activation, enable all Air Handling Units to operate in occupied mode, override mixing dampers to 100 % outside air, command heating valves open and cooling valves shut.

c. Wait a delay of 5 minutes. For Test AH3 compare the calculated SAT-MAT to the design heating capacity less the heating capacity tolerance and if SAT-MAT is less than the calculated criteria, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT) < (HDdT – HDdT*TT) THEN FAIL]. A low rise in supply air over mixed air temperature is an indication of control valve problems or low water flow. For Test AH4 compare the calculated outside air percentage to the tolerance and if less than the tolerance, indicate test failure, otherwise indicate test pass [IF %OSA < TT, THEN FAIL]. A low quantity of outside sir indicates leaking return dampers, damper slipping on shaft or broken damper motor.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

13. Air Handling Unit Test AH5 Chilled Water Valve Leak Test

a. Disable Test AH5 if the chilled water loop temperature is above Maximum Allowed CWS Temperature Lockout Set Point.

b. Upon Test AH5 activation, enable all Air Handling Units to operate in occupied mode and command all chilled water and heating water valves full closed

c. After a delay of 5 minutes, compare the calculated SAT-MAT to the leakage tolerance and if greater than the tolerance, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT) > TT, THEN FAIL]. An excess drop in supply air over mixed air temperature is an indication of a leaking cooling valve.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

14. Air Handling Unit Test AH6 Cooling Capacity

a. Disable Test AH6 if the chilled water loop temperature is above Maximum Allowed CWS Temperature Lockout Set Point.

b. Upon Test AH6 activation, enable all Air Handling Units to operate in occupied mode, command all AHU cooling valves full open and heating valves full closed.

c. After a delay of 5 minutes, compare the calculated SAT-MAT to the design cooling capacity less the cooling capacity tolerance and if SAT-MAT is less than the calculated criteria, indicate test failure, otherwise indicate test pass [IF ABS(SAT-MAT < (CDdT-CDdt*TT) THEN FAIL]. A low drop in supply air under mixed air temperature is an indication of control valve problems or low water flow.

d. When test initiation Enable is released, release all overrides and return system to pre-test status, clear Enable indication.

e. Disable test after a period of time equal to the Automatic Disable value, initially set at 15 minutes (user adjustable), clear Enable indication.

15. Companion Trend Logging
    a. Trend logs are to be set up to monitor the AFTS. The following points are to be trended at 1-minute intervals for a minimum of 8 hours.
        i. Outside Air Temperature
        ii. Supply and Mixed Air Temperature for each Blower Coil
        iii. Supply Air Temperature and Measured Air Flow for each VAV Terminal Unit
        iv. Supply, Return and Mixed Air Temperature for each AHU.
        v. Duct static pressure for VAV air handlers.
        vi. Hot water and chilled water supply and return temperatures
        vii. Test pass/fail status for each test.
16. Commissioning
    a. The Contractor is responsible for the safety of all equipment and personnel as it relates to the equipment and should fully review the sequence of operations for issues prior to implementing the sequences.
    b. The Contractor shall fully test and document the proper operation of all aspects of the AFTS. The Commissioning Authority will provide the test procedures and forms to be executed by the Contractor.

Exhibits

The following exhibits are provided to indicate a general layout for the graphics screens. The control contractor shall provide a proposed layout for approval by the Owner and Commissioning Authority prior to implementation.

The following abbreviations apply in the exhibits:

S/S = Start/Stop button or check box to activate/deactivate the test
B = Navigation button
CV = Calculated Value
PV = Process Value
UAV = User Adjustable Variable or Set Point
P/F = Display Pass or Fail based on parameter comparison to tolerance

Exhibit 1 Automated Functional Test Main Proposed Screen

Automated Functional Testing System Main Menu

Instructions:

(Finalized instructions will appear on graphics)

Blower Coil Tests		VAV Terminal Unit Tests		Air Handling Unit Tests	
B	Test BC1 Heating Valve Leakage	B	Test V1 – Zero Flow	B	Test AH1 Heating Valve Leakage & Test AH2 OSA Damper Leakage
B	Test BC3 Chilled Valve Leakage	B	Test V2 – Damper Leakage	B	Test AH3 Heating Capacity & Test AH4 Return Air Damper Leakage
B	Test BC2Heating Capacity	B	Test V3&V4 – Cooling Flow & Heat Valve Leakage	B	Test AH5 Chilled Valve Leakage
B	Test BC4 Cooling Capacity	B	Test V5&V6 – Heating Flow & Heating Capacity	B	Test AH6 Cooling Capacity
PV	Outside Air Temperature	PV	HWS Temperature	PV	CWS Temperature

Exhibit 2 – Blower Coil Proposed Screen Layout

Blower Coil Automated Functional Tests

S/S	Test BC1 Heating Valve Leakage	S/S	Test BC2Heating Capacity	B	Return to Main Menu
S/S	Test BC3 Chilled Valve Leakage	S/S	Test BC4 Cooling Capacity		

UAV	BC1 Tolerance (deg F)	UAV	BC3 Tolerance (deg F)	PV	MAU SAT (deg F)
UAV	BC2 Tolerance (% HDdT)	UAV	BC4 Tolerance (% CDdT)	PV	Outside Air Temperature(deg F)
PV	Hot Water Supply (deg F)	PV	Chilled Water Supply (deg F)	UAV	Automatic Disable (minutes)
PV	Hot Water Return (deg F)	PV	Chilled Water Return (deg F)		
UAV	Min Required HWS Lockout (deg F)	UAV	Max Allowed CWS Lockout (deg F)		

Maximum Allowed CWS Temperature Lockout Set Point

BC	HDdT	CDdT	RAT	MAT	SAT	BC dT	Test BC1	Test BC2	Test BC3	Test BC4	
1	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	
2	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	
3	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	
Etc.											

Key:
HDdT = Heating Design Differential Temperature CDdT = Cooling Design Differential Temperature
RAT = Return Air Temperature MAT = Mixed Air Temperature SAT = Supply Air Temperature
BCdT = The Absolute Value of SAT minus MAT
Note: Control Contractor to provide key customized to any abbreviations used.

Exhibit 3 – VAV Test Proposed Screen Layout

VAV Terminal Unit Automated Functional Tests

S/S	Test V1 – Zero Flow	S/S	Test V2 – Damper Leakage	S/S	Test V3 – Cooling Flow Test V4 – Heat Valve Leakage
S/S	Test V5 – Heating Flow Test V6 – Heating Capacity	B	Return to Main Menu	B	Next Group of VAVs

UAV	V1 Tolerance (% CDAF)	UAV	V2 Tolerance (% CDAF)	UAV	V3 Tolerance (% CDAF)
UAV	V4 Tolerance (deg F)	UAV	V4 Tolerance (% HDAF)	UAV	V6 Tolerance (% HDdT)
UAV	Automatic Disable (minutes)	UAV	Min Required HWS Lockout (deg F)	PV	VAV AHU1 DSP (“W.C.)
PV	VAV AHU1 SAT (deg F)	PV	Hot Water Supply (deg F)	PV	Hot Water Return (deg F)

VAV	HDdT Deg F	CDdT Deg F	HDAF cfm	CDAF cfm	FSP	MAF	VAVS AT	VAV dT	Test V1	Test V2	Test V3	Test V4	Test V5	Test V6
1	UAV	UAV	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	P/F	P/F
2	UAV	UAV	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	P/F	P/F
3	UAV	UAV	UAV	UAV	PV	PV	PV	CV	P/F	P/F	P/F	P/F	P/F	P/F
Etc.														

Key:
HDdT = Heating Design Differential Temperature CDdT = Cooling Design Differential Temperature
HDAF = Heating Design Air Flow CDAF = Cooling Design Air Flow FSP = Flow Set Point MAF = Measured Air Flow
SAT = Supply Air Temperature VAV dT = The Absolute Value of VAV SAT minus AHU SAT
Note: Control Contractor to provide key customized to any abbreviations used.

Exhibit 4 - AHU Tests Proposed Screen Layout

Air Handling Unit Automated Functional Tests

S/S	Test AH1 Heating Valve Leakage & Test AH2 OSA Damper Leakage	S/S	Test AH3 Heating Capacity & Test AH4 RA Damper Leakage	S/S	Test AH5 Chilled Valve Leakage
S/S	Test AH6 Cooling Capacity			B	Return to Main Menu

UAV	AH1 Tolerance (deg F)	UAV	AH2 Tolerance (%OA)	UAV	AH3 Tolerance (% HDdT)
UAV	AH4 Tolerance (% OA)	UAV	AH5 Tolerance (deg F)	UAV	AH6 Tolerance (%CDdT)
UAV	Automatic Disable (minutes)	UAV	High OA Lockout (deg F)	UAV	Low AO Lockout (deg F)
PV	Outside Air Temperature(deg F)	PV	Hot Water Supply (deg F)	PV	Hot Water Return (deg F)
UAV	Min Required HWS Lockout (deg F)	PV	Chilled Water Supply (deg F)	PV	Chilled Water Return (deg F)
UAV	Max Allowed CWS Lockout (deg F)				

AHU	HDdT	CDdT	RAT	MAT	SAT	AHU dT	%OA	Test AH1	Test AH2	Test AH3	Test AH4	Test AH5	Test AH6
1	UAV	UAV	PV	PV	PV	CV	CV	P/F	P/F	P/F	P/F	P/F	P/F
2	UAV	UAV	PV	PV	PV	CV	CV	P/F	P/F	P/F	P/F	P/F	P/F
3	UAV	UAV	PV	PV	PV	CV	CV	P/F	P/F	P/F	P/F	P/F	P/F
Etc.													

Key:
HDdT = Heating Design Differential Temperature CDdT = Cooling Design Differential Temperature
RAT = Return Air Temperature MAT = Mixed Air Temperature SAT = Supply Air Temperature
AHU dT = The Absolute Value of SAT minus MAT %OSA = % Outside Air = (MAT-RAT)/(OAT-RAT)
Note: Control Contractor to provide key customized to any abbreviations used.

3.17 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230900

SECTION 230923 - DIRECT DIGITAL CONTROL SYSTEMS (DDC)

PART I - GENERAL

1.1 RELATED DOCUMENTS: See Sections 230700, 230923 and 230933.

1.2 DESCRIPTION OF WORK:

A. A integrated facility management system shall be bid for this project. The entire system to be complete for all required control functions. Price to comprise a complete control price for the work required.

B. To include all components, materials and installation covered by Section “Electric Control Systems” and to be fully integrated with the same.

C. To include all control wiring initiating with power from the distribution panel(s) at line voltage (provide circuit breaker) and extending to transformers, devices, components, etc. which comprise a part of the system.

D. Description:

1. It is the intent of this specification to describe the basic architecture and performance requirements of the Facility Management System (FMS). The FMS shall be based on a distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on a true peer-to-peer, token passing Local Area Network (LAN), called the Controller LAN. All "primary" equipment shall be served by stand alone controllers residing directly on this Controller LAN. System architectures with primary equipment controllers residing on master/slave (polling) networks or sub-networks will not be acceptable. The Facility Management System shall include all work station software and hardware, Distributed Control Units (DCUs), Local Area Networks (LANs), sensors, control devices, actuators, installation and calibration, supervision, adjustments and fine tuning necessary for a complete and fully operational system.

2. This FMS shall include an integrated Access Control System which shares work stations, DCUs, and LANs. In addition, the Access Control functionality to be provided shall include Door Processing Units (DPUs), readers, locking devices, and commissioning for a complete and operational system.

3. Each installation shall comply with local, state, and federal code requirements as applicable.

4. Provide a two year warranty on hardware, software, and firmware for all items provided by the control system manufacturer.

1.3 QUALITY ASSURANCE: See Section 230900.

This specification wording is based on CSI product line.

1.4 SUBMITTALS: See Section 230900.

1.5 DELIVERY, STORAGE AND HANDLING: See Section 230900

1.6 INSTRUCTION OF OWNER PERSONNEL: See Section 230900.

1.7 WARRANTIES: See Section 230900.

1.8 CLEANING AND LUBRICATION: See Section 230900.

1.9 TESTING AND ADJUSTING OF SYSTEM: See Section 230900.

1.10 OPEN PRICING: Vendors shall make detailed cost breakdowns of this work available to Owner during period of evaluation of the project to aid in identifying costs and benefits of this system.

PART II - PRODUCTS

2.1 GENERAL:

A. All sensors, transmitters, flowmeters, detectors, controllers and other associated temperature control equipment locations shall be submitted for approval before installation. Finish shall be manufacturer's standard unless otherwise noted on the drawings.

B. All sensors and sensor/transmitters when utilized as dual set-point devices, as indicated on the drawings, shall be provided with a software interlock which provides a programmable heat/cool deadband in compliance with ASHRAE 90-75.

C. All sensors and transmitters shall be capable of being replaced without the need for controller recalibration.

2.2 CONTROL CABINETS: See Section 230900.

A. Panel mount all controllers and devices other than remote sensors and operators. Provide permanent labels, terminal blocks, etc.

2.3 POWER SOURCES:

A. Power Supply:

1. Furnish complete power supply for all box controllers at appropriate voltage and in adequate capacity. Provide multiple power supply devices, mount conveniently in custodial closets or spaces as directed. Load power supply units to no more than 70 percent of nameplate capacity.

2. Run all power wiring in conduit, neatly arranged and coordinated with other trades.

3. Group boxes served by each power supply unit in proximity, provide permanent mounted schedule of boxes served by each power supply.

B. Communications Conductors:

1. Connect each and every VAV box controller back to the Central Direct Digital master controller with required conductors) shielded cable. (Beldon #18 gauge "Beldfoil 8760 or equivalent). Avoid common conduit with AC voltage or inductive loads. All in accordance with National Electric Code, conductors in conduit (3/4" minimum).

2.4 DAMPERS: See Section 230900.

2.5 ELECTRIC DEVICES: See Section 230933.

2.6 PRESSURE TRANSMITTERS:

A. Differential or Gauge (static) Pressure Transmitters shall be solid state capacitance type. Transmitters shall have an output of 4 to 20 MA DC in accordance with ISA Standard 550.1 and shall operate from a power supply of 15 to 32 volts DC. Total affects of hysteresis, linearity and repeatability shall be plus or minus 1.0 percent of full scale or less, and repeatability shall be less than 0.3 percent of full scale. Variations in output signal per input supply voltage shall not exceed 0.02 MA output per 1.0 volt input change. The transmitters shall be totally enclosed, and shall have factory set zero and span adjustments that are accessible without removing the cover. Transmitters shall not be damaged by pressures at five (5) times the full scale pressure and shall be selected for the appropriate pressure range.

2.7 ROOM TEMPERATURE SENSORS:

A. Room Temperature Sensors shall be a CSI TTS100 Slide/Stat. Unless indicated on the drawings, sensors shall have nonindicating tamper resistant covers with setpoint adjustment slide. Sensors rated for use in air plenum shall have brushed aluminum or stainless steel covers.

B. Unless indicated on the drawings, sensors shall have a plug-in jack for the manufactures standard portable operators terminal. The jack shall be concealed under the cover to prevent tampering.

2.8 IMMERSION THERMOWELLS:

A. Thermowells shall be monel, brass, or copper for use in copper water lines; wrought iron for measuring flue gases; and 300 series stainless steel for all other applications. The thermowell shall include a connection box as required for the applicable transmitter.

2.9 PRESSURE SWITCHES:

A. Pressure Switches shall have a repetitive accuracy of plus or minus 2 percent of the operating range. Pressure Switches shall be the diaphragm type with adjustable actuation over the operating range. The switches shall have snap action form C SPDT or DPDT contacts rated for the application.

2.10 TEMPERATURE SWITCHES:

A. Temperature Switches shall have a repetitive accuracy of plus or minus 2 percent of the operating range. Actuation shall be adjustable over the operating range. The switches shall have snap action Form C SPDT or DPDT contacts rated for the application.

2.11 DAMPER AND VALVE ACTUATORS:

A. Damper and Valve Actuators shall be electric. Actuators shall be UL listed, diecast aluminum casing, rated for an ambient environment of -40 degree to 140 degree Fahrenheit. Actuators shall be properly sized to provide sufficient torque for the application and shall have field adjustable shaft rotation. Actuators shall be spring return where applicable for N.0. or N.C. dampers or valves as required. Actuators shall be provided with all linkage and mounting hardware required for the valve or damper actuation.

2.12 CONTROL VALVE:

A. Control Valves shall be two-way or three-way pattern as shown on the plans or specified. Provide valves constructed for tight shut-off with the body material and pressure class to operate against the system pressures and differentials. Except as otherwise indicated, provide valves which mate and match material of connecting piping. Equip control valves complete with factory mounted actuators with the appropriate torque rating for tight shut-off.

B. Water service valves for modulating control of hot or chilled water shall have equal percentage characteristics and maximum full flow pressure drop of 5 psig.

C. Two position control valves shall be line sized.

D. Unless otherwise shown or specified valves shall have polished stainless steel stems and trim, self adjusting spring loaded teflon packing with bronze body and bonnet.

2.13 CONTROL RELAYS:

A. Control Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million mechanical operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage.

2.14 CONTACTORS:

A. Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contacts shall be double break silver to silver type protected by arcing contacts where necessary. Number of contacts and ratings shall be selected for the application. Contactors shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage.

2.15 END (LIMIT) SWITCH:

A. Limit Switches shall be of the enclosed or sealed type as required for the application. Contacts shall be snap-action Form C rated for the application.

2.16 POTENTIOMETERS:

A. Potentiometers may be either rotary or linear, depending on the application of each position indicator. Position potentiometers shall have a linearity of plus or minus 5 percent and shall indicate position on a percent open basis.

2.17 CO2 SENSOR:

A. INTEC, Q AC

2.18 STATUS SENSOR CURRENT TRANSDUCER:

A. Hawkeye Series 700, 4-20 mA output.

2.19 TRANSDUCERS: Where analog outputs are required, provide 4-20ma or 0-10 VDC outputs.

2.20 TEMPERATURE SENSORS: Provide thermistor or thin film silicon sensors for all temperature applications, except differential chilled water for BTU calculation, where precision matched Platinum RTDs shall be used. Solid state sensors shall be linear, drift free, and require only a one time calibration. Thermistors, or similar non-linear temperature devices shall be linearized by a look-up table in the connected controller. Resolution shall be better than .5 degrees F for Micro Controller applications, and better than .2 degrees F for DCU applications. Sensors shall be designed for duct, duct immersion, immersion, strap-on, or outdoor mounting as indicated on the drawings.

2.21 CENTRAL WORK STATION HARDWARE:

A. The Guard’s IT department will provide any local PC needed for this project. This will enable the guard to match this computer with others they have furnished throughout the BMS system.

B. The Central Computer located in Draper HQ will have all programming and graphics loaded on their computer for this project and a Net Plus router will be provided so that the two buildings can communicate with each other.

2.22 LOCAL AREA NETWORKS (LAN):

A. Controller LAN: The FMS shall provide communication between the DCU's over a Local Area Network (LAN).

1. The Controller LAN shall be a high speed "bus type" network over which information is transmitted in a "global" fashion between all the nodes on the network.

2. The Controller LAN shall have the capacity to contain not less than 64 nodes as a minimum. Each work station, DCU, or "gateway" device shall represent a node to the network.

3. The Controller LAN shall connect the nodes in a fully distributed environment, each DCU operating autonomously while communicating with all other nodes on the

network. Controller LANs requiring a communication controller (for any reason) will not be acceptable. LAN lengths in excess of 24,000 ft. shall be supported.

4. A break in the communication path of the Controller LAN shall be announced as an alarm and shall automatically initiate a Controller LAN reconfiguration such that the resulting sections of the Controller LAN continue to function as separate LANs. No loss of control shall result from such a break in the Controller LAN.

B. Commercial LAN: Work stations on the Controller LAN may also reside on a higher tier "commercial" LAN. This "commercial" LAN shall be based on Ethernet, and comply with IEEE 802.3 standards. Where a "commercial" LAN is implemented, it shall be possible to connect multiple Controller LANs together, with global data sharing across this commercial LAN.

1. Data speed shall not be less than 10 Megabaud.

2. The "commercial" LAN shall support up to 63 work stations, including as many as 8 dedicated backup work stations serving to continuously backup the database on the other work stations. A single work station shall be able to be backed up by more than one backup work station.

3. An operator at a work station on the "commercial" LAN may connect to any other work station on the "commercial" LAN as if the operator were sitting at the other work station.

4. Alarms and special event notices shall be routed to different work stations on the "commercial" LAN based on time of day, and day of the week.

5. Operator password assignment shall be available on both a system-wide basis and a workstation by workstation basis.

2.23 TRANSMISSION SYSTEM:

A. The FMS shall utilize the above LAN architecture to allow all of the Distributed Control Units to share data as well as to globalize alarms. The Controller LAN shall be based on a peer-to-peer, token passing technique with a data speed of not less than 19.2 Kbs. Systems which require a "master" communications controller or network manager for the Controller LAN are not acceptable.

B. Communication Techniques: The Controller LAN shall support node interface devices for the work stations which shall function as a "gateway" to convert, buffer, and filter the Controller LAN data to the RS-232 data port of the PC work station. These "gateway" devices shall support local hardwired work stations as well as auto-answer/auto-dial modems and remote pagers. The "gateways" shall allow PC work stations to interface to the Controller LAN at any point on the network directly or via telephone lines without having to be connected to a DCU in order to communicate with the system.

C. Network Support: The "turnaround time" for a global point to be received by any node, including operator stations, shall be less than 3 seconds. The Controller LAN shall provide for automatic reconfiguration if any station (Distributed Control Unit, PC work station, gateway, etc.) is added or lost. Should the transmission cable be cut, the two sections shall reconfigure with no disruption to the system's operation and without any operator intervention.

D. Network Trees & Summaries: Provide automatic, on-line configuration summaries listing each device or node on each tier of a multi-tiered FMS system architecture. Separate summaries shall exist for: Controller LAN, Commercial LAN (if used), and MicroController (MC) network (if used). Each summary shall list the point address/name, the device type,

the device name, the revision level, and the revision date.

2.24 FIELD HARDWARE:

A. Distributed Control Units (DCU): All points in the system shall be monitored and/or controlled through "intelligent" Distributed Control Units (DCU's). Each DCU in the system shall contain its own microprocessor and memory with a minimum 300 hours battery backup. Each DCU in the system shall be a completely independent stand-alone "master" with its own hardware clock calendar and all firmware and software to maintain complete control on an independent basis. Each DCU shall include the following capabilities:

1. Acquire, process, and transfer information to the PC operator work stations or other DCU's on the network.

2. Accept, process, and execute commands from the other DCU's or other input devices, or multiple PC work stations.

3. Allow access to both data base and control functions by multiple work stations at the same time.

4. Record, evaluate, and report the changes of state and/or value that occur among points associated with the DCU. If any operator work station or transmission network fails, but the power to the DCU does not, the DCU shall continue to perform all control functions associated with the points to which the DCU remains connected.

5. Specifically, a DCU shall contain memory and processing capability to perform in a stand-alone mode:

a. Scheduled start/stop
b. Adaptive optimized start/stop
c. Duty cycling
d. Automatic temperature Control
e. Demand control via a sliding window, predictive algorithm
f. Event initiated control
g. Calculated point
h. Scanning and alarm processing
i. Full Direct Digital Control
j. Trend logging
k. Global communications
l. Maintenance scheduling

B. DCU Global Communications: Each DCU shall have the ability to transmit any or all I/O points as global points onto the network for use by other DCU's and to utilize data from other panels as part of its data base. To maximize system throughput, and minimize unnecessary network traffic, analog inputs shall be transmitted only after an operator specified change of value has occurred since the last broadcast value. This change of value threshold shall be operator selectable on a per point basis.

C. DCU Field Input/Output Capability: The following point types must be supported by the DCU's.

1. Discrete/digital input (contact status).

2. Discrete/digital output (maintained, momentary, dual momentary, floating).

3. Analog input (0-20 mA, or 0-5 VDC or 0-10VDC with 12-bit A/D conversion resolution minimum).

4. Analog output (0-10 VDC with 8-bit D/A resolution minimum).

5. Pulse input capable of accepting 10 pulses/second and accumulating total.

6. Pulse Width Modulation (PWM) output capable of producing a pulse anywhere

between 0-655 seconds in duration with 0.01 second resolution.

7. Every discrete/digital output and PWM output shall have an HOA switch with individual feedback as to the position of the switch, unless the DCU has an integral keypad/display device.

D. Each DCU shall have the ability to monitor, control or address not less than 300 data points.

E. DCU Point Scanning: It shall be possible to independently set the scan or execution speed for each point in the DCU to an operator selected time from 1 to 254 seconds.

F. DCU Upload/Download Capability: Each DCU shall be able to download from or upload to any PC operators work station. All point data shall be modifiable from any authorized PC operators work station and downloaded to the DCU over the Controller LAN. It shall not be necessary to enter parameters locally at the DCU for control programs to take effect. This upload/download shall be readily performed on a regular basis without interrupting the control functions in the DCU. All upload/downloads shall be performed without the operator workstation being taken "off-line", and shall be completed in no more than 15 seconds.

G. DCU Diagnostics: provide diagnostics which support the following dynamic (one second refresh) parameters:

1. Processor Loading
2. LAN Loading
3. Memory data

H. DCU Test Mode Operation: Each DCU shall have the ability to place input/output points in a test mode. The test mode shall allow control algorithms to be tested and developed on line without disrupting the field hardware and controlled environment. The treatment of all I/O points in the test mode shall be as follows:

1. Scanning and calculation of all input points in test mode shall be inhibited. Manual control of input points in test mode will allow setting the analog or digital input point to an operator determined test value, which can be issued from any fixed or portable operator console.

2. It shall be possible to control all output points, but only the data base state/value shall be changed - the external field hardware is left unchanged. Failure to provide test mode capability will preclude acceptance.

I. DCU Local Operator Console: Furnish at each DCU location provisions for connection of a local operator's console. Furnish one portable type local operator console for the project. If the console is not of the portable type, a permanent door mount type with display shall be provided at each DCU. The console shall be capable of full global communications with all DCU's on the Controller LAN when connected to any DCU on the Controller LAN. It shall be possible to perform as a minimum the following functions through the local operator console:

1. Set/display date.

2. Set/display time.

3. Display the status or value of all points connected to the DCU or any other DCU on the Controller LAN.

4. Control the outputs connected to the DCU or any other DCU on the Controller LAN.

5. Enable/disable any or all automatic control outputs.

6. Perform DCU diagnostic testing.

7. Place any or all points in "Test" mode.

8. Display DCU CPU "percentage processing time" so that system and DCU processor loading may be determined. Also, display the amount of DCU programming memory available and the amount currently used.

    a. Where a portable, laptop, or notebook PC is provided as the local operator console, the operator interface shall be identical to the primary PC work station, and require no additional training to operate.

J. MicroController Interface: Micro Controllers(MCs) shall be connected to the Controller LAN via a Micro Controller Interface (MCI). The MCI shall be a DCU without any directly connected points. MCs shall be connected to the MCI via a high speed, RS-485 sub-network. For system reliability, distribution of risk, and high throughput, not more than 64 MCs shall be connected to any single MCI, and this MCI shall not share processors or Controller LAN interfaces with a DCU that is hardwired to primary equipment.

1. The MCI shall provide common, and memory intensive functions for locally connected MCs, including: time scheduling, custom or global calculations, and historical data collection. The operator interface for all MCI database entry and application programs shall be fully integrated and consistent with other DCUs.

2. The MCI shall support sub-networks consisting of counter-scanning loops for increased system availability. Upon a single break (i.e., severed wire) the MCI shall scan the loop in both the primary and secondary directions and maintain communications with all MCs - not just those located between the MCI and the fault.

K. Micro Controllers: Micro Controllers (MCs) shall be utilized for zone or terminal equipment only. Applications requiring more than 8 inputs and 8 outputs are not considered zone or terminal and must be treated as "Primary" equipment applications, which require direct connection to a DCU on the Controller LAN. Micro applications include:

1. Blower coils, AHUs

2. No Potentiometers, batteries, filters, or other maintenance items shall be present on the MC. All database entry for the MCs shall be via "prompting" editors at the primary PC work stations. The database entry and personality assignment of the MC shall be fully integrated and consistent with all other points in the system, whether resident in a DCU or a MC. All programs shall be contained on the MC in firmware, and all database shall be contained on the MC in nonvolatile NOVRAM. All input and output points in the MC shall be available for display, command, and on-line editing at the primary PC work stations. Points unused by the local terminal unit application, may function as a system point.

3. Triple setpoints shall reside in each MC for both heating and cooling: Occupied, Unoccupied, and Economy. Occupied and Unoccupied shall follow the time schedule, or other event initiator in the MCI. Economy setpoints shall be activated to widen the Occupied deadband during periods of high electrical demand, in lieu of duty cycling or load shedding the terminal equipment.

4. To ensure "tight" integration between all system hardware and software, as well as long term component availability, the MCI, MC, and MC sensors shall be originally manufactured by the same manufacturer who supplies the DCUs, Controller LAN, and workstation application software. Private labeling of these components does not fulfill this requirement.

2.25 FMS SOFTWARE - GENERAL:

A. This Contractor shall provide all software required for efficient operation of all the automatic system functions required by this specification. Software shall be modular in design for flexibility in expansion or revision of the system. It is the intent of this specification to require provisions of a system which can be fully utilized by individuals with no, or limited, previous exposure to PC's and programming techniques and languages. If the system to be provided requires the use of any modified BASIC, "C", PASCAL, or DRUM Language

program, or writing "line" programming statements to modify operation or strategy in the system, the vendor shall provide unlimited, no charge, software modification and support for a period of five (5) years after the completion of the project in addition to the warranty period specified elsewhere. Systems which are factory programmed are unacceptable.

B. The software shall include a General Purpose Operating system, as well as Facility Management System Application software. All available vendor work station application software shall be provided with the system, and shall reside in each and every PC. "Unbundled" software packages where the vendor can charge the user extra fees, or require dedicated work stations, or require system rebooting for access, are unacceptable.

C. The software in the system shall consist of both "firmware" resident in the DCU's and "software" resident in the operator work stations. The architecture of the system, and the application software/firmware shall be distributed with no single system component responsible for a control function for the entire Controller LAN. Each DCU shall contain the necessary firmware and I/O capability to function independently in case of a network failure. No active energy management or environmental control sequences shall be resident in the PC work stations. All PC work stations shall be removable from the system without loss of control function - only alarm monitoring, long term history collection, and operator monitor/command/edit functions would be lost.

2.26 BUILDING MANAGEMENT SYSTEM SOFTWARE:

A. The TAC/INET software is owned by the state. The latest version of this software will be provided at no additional cost.

B. The primary operator interface to the system shall be through a graphical, "object oriented", interactive presentation using a mouse and cursor for object selection and commands.

1. The system shall support an operator definable “default” system page. The default system page shall be displayed upon system startup, operator activity time-outs, and when the system is not in use. This default system page may be any one of the standard dynamic graphic pages, or may be a custom display developed for this purpose. The operator shall be able to display their corporate logo, emergency information, an index of all graphic pages, etc. as the default system page.

2. The cursor shall be a "floating arrow".

3. The system shall support "pop-up" windows for point commands. On selecting an object with the cursor, a window shall open up to present the operator with choices corresponding to the operator's password authorizations. These point commands shall include state changes, manual override of application software, test mode activation and test value entry. This window shall include, for reference, the point's descriptor (name), the point's hardware address, and alarm status.

4. The system shall support "pop-up" windows for point editing. On selecting an object with the cursor, a window shall open up to present the operator with a list of active point database editors, if permitted by the operators password level. Selecting one of these editors shall allow the operator to modify the basic parameters associated with a point, as well as access any programs assigned to the point (such as time schedules, calculations, events, etc.).

5. The system shall be based on interactive prompts and choices, using "dialog boxes" as opposed to memorization of commands, "syntax", exact spellings, etc. This interactive prompt and choices approach shall be used in monitoring, issuing commands, and editing. Command choices shall be as simple as "clicking" the cursor over the correct word choice prompts (i.e., ON OFF), without typing in the letters. Editing mode choices shall prompt with ranges or options (i.e., 16 CHARACTERS for point name, or DIRECT/REVERSE for action).

6. Dynamic Graphic Flow Chart Programming: The operator shall have the ability to construct "dynamic" graphic flow charts of system control sequences, while the system is on-line. This flow chart utility shall be usable both for on-line control logic development (i.e., programming), and for live displays of the interactive process variables occurring throughout the sequences of operations. Flow chart elements shall consist of "Icons" selected from a "toolkit". Discrete Icons shall exist for:

   a. Each point type (AI, DO, etc.)

   b. Each DDC Module or Block

      (1) Analog output PID
      (2) Floating output PID
      (3) Two position output (thermostatic control)
      (4) Reset (with secondary input bias)
      (5) High/Low selector (4 input, dual output)
      (6) Relay
      (7) Relay, Delay before break
      (8) Relay, Delay before make
      (9) Relay, Interval timer

   c. Each Application program appended to a point

      (1) Calculations
      (2) Event sequences
      (3) Time schedules
      (4) Demand control
      (5) Trend
      (6) Runtime
      (7) Consumption
      (8) Alarm inhibit/enable
      (9) Micro control (AHU, Heat Pump, VAV, PID)

   d. "Lines" (values passed between DDC modules or points)

   e. Pages

   f. Doors (access control)

   g. The cursor and mouse shall be used to place the Icons on the graphic, and to connect the Icons (where meaningful) with "lines". "Lines" shall display the current state or value of data passing between Icons, or Modules.

      (1) Text may be inserted into the graphic to describe the sequence of operation in sentence format. Once completed the graphics shall be able to be printed out for permanent records.

   h. During and/or after completing construction of the dynamic graphic flow chart, the cursor may be placed on the Icon, and by "clicking" the mouse, the Icon may be exploded into the associated database editor for adding, deleting, or modifying the point, module, or application program. Similarly, the point may have its "pop-up" window called up to issue point commands, or overrides. Systems requiring graphic programming languages which are off-line, or require time delays for compiling, or which are not integrated into the primary operator work station are not acceptable.

7. Zoom: It shall be possible for an operator to locate any system point to monitor status, issue commands, or edit associated database without knowledge of the point's name, address, or associated controller, and without having to refer to a "tree" directory. The operator shall be able to zoom in on a building in a campus graphic, zoom in on a floor in a building graphic, zoom in on a system in a floor plan graphic, etc.

C. The system software shall be compiled for faster execution speeds and shall offer all of the following features and capabilities:

1. Input/Output Capabilities: From any local PC work station or any remotely connected PC work station, the system operator shall have the capabilities through the keyboard/mouse to:

a. Request dynamic displays of current values or status using a tabular or graphic format. A global database sort utility shall allow an expanded tabular display of only the points on the current graphic display. This expanded tabular display shall list point name, hardware address, dynamic state or value, alarm status, override status, and test mode status.

b. Command selected equipment to a specified state.

c. Initiate logs and reports

d. Change analog limits

e. Obtain a summary of all access control doors with status (under access control, access control disabled, or access control ignored) and allow issuing commands to the access control doors to manually force the door to one of the above states, or provide a momentary release (act as a valid key/card access), or return to automatic control (remove manual state).

f. Add, delete, or change points within each DCU or application routine.

g. Change point I/O descriptors, status, and alarm descriptors and engineering unit descriptors while the system is on-line.

h. Add new DCUs and MCs to the system while the system is on-line.

i. Modify and set up maintenance scheduling parameters.

j. Develop, modify, delete or display full range of colorgraphic displays providing dynamic, animated displays. All development, editing and display work shall be performed with the system fully on line and in full communications with the Controller LAN.

k. Select discrete or analog sample data from the field to be automatically archived in the assigned work station.

l. A comprehensive report writer capability shall be provided in each work station to sort and extract data from the archived files and to generate finished custom reports. Reports shall be capable of manual initiation and/or printout as well as automatic printout. The system will have the capability to print reports on a daily, weekly, monthly, yearly or scheduled basis. The system will have the capability to print reports as a result of an “event”. This report writer shall provide the capability for statistical data manipulation and extraction. As a minimum the custom report writer must provide the capability to generate four types of reports: 1) Statistical detail reports, 2) Summary reports, 3) Trend graphic plots for up to four variables, 4) x-y graphic plots.

(1) This report function shall be "on-line" for both development and printout, and shall not require export to a third party spreadsheet program for execution.

(2) In addition to this "on-line" function, the historical database shall be capable of being converted to Data Interchange Format (DIF) for use in third party spreadsheet programs such as Lotus 1-2-3, for off-line manipulation. Transmission to DIF files shall be manual, event driven, or automatic based on operator selectable parameters

including: time of day, frequency (daily, weekly, monthly, yearly), scheduled days (32 days minimum). File transfer shall support "appending" new data to the existing file data.

m. The alarm printer will print all alarm annunciations and return to normal, operator acknowledgments, action messages, system alarms, operator sign-on and sign-off. All operator control activities shall include the operators initials in the printed and disk record.

n. The printer shall also be used for printing reports, page prints, and data base prints. Both printer functions shall be available from any PC work station.

o. The operator will have the option of selecting daily, weekly or monthly as a scheduled frequency to synchronize time and date in Distributed Control Units from the PC workstation. This function will be performed for dial up as well as direct connected locations. This program shall accommodate automatic daylight savings time adjustments.

p. The operator may print a selected Distributed Control Unit data base whenever desired. The operator shall be able to select any or all control parameters as needed. A "bindable" printout of the database of each DCU (including MCs), with a floppy disk backup shall be submitted with "as-builts" as part of the final acceptance procedure.

q. The CRT shall have a feature to indicate audibly and visually, Off-Normal conditions and messages pending, whether in FMS operating mode or third party software mode.

r. The operator may request a summary of all points on the Controller LAN currently in the "test" mode or in an off-normal condition.

2. Operator Access: Operator access to the FMS shall be via software password at every PC work station and at each DCU. Over 1000 passwords/operators shall be supported. The owner will not be constrained to fixed password levels, but may enable any or all the following functions for any operator:

a. COMMAND FUNCTIONS

(1) View graphic pages
(2) Test-on/Test-off
(3) Point monitor
(4) Alarm acknowledgment
(5) Point control
(6) Manual override
(7) View summaries
(8) Exit from FMS to DOS

b. DATABASE FUNCTIONS

(1) Passwords
(2) Graphic pages
(3) Report generator
(4) Trend sampling
(5) Message routing
(6) Off-line database editing
(7) DCU database save & restore
(8) On-line database editing
(9) Holiday schedules
(10) DDC control modules
(11) Time schedules
(12) Event sequences
(13) Calculations
(14) Demand control parameters
(15) Micro controller parameters

(16) Runtime parameters
(17) Access control parameters

3. Data Base Creation and Support: The intent of this specification is to provide an FMS system which will allow the owner to independently perform his own modifications to the system from any operator work station. All changes shall be done utilizing standard procedures and must be capable of being done while the system is on-line and operational. The DCU on the Controller LAN shall automatically check a PC work station's data base files upon connection to verify a current data base match. A utility shall inform the operator if the DCU's database files do not match the backup files stored on the PC workstation, along with the date of last DCU modification and date of last backup. The owner must have as a minimum, the on line capability to:

a. Add and delete points.

b. Modify any point parameter.

c. Determine which PC work station(s) points will be directed to, on a point by point basis.

d. Change, add, or delete English language descriptors (i.e., name). System I/O points may be identified either by name or by it's logical address. Up to 16 characters shall be available for the English language descriptor, which shall be used in all control sequences. Use of a second abbreviated point "name" for control sequences is unacceptable complexity.

e. Add, modify, or delete alarm limits.

f. Add, modify, or delete points in start/stop programs, trend logs, etc.

g. Create custom relationship between points. A general purpose user utility shall be provided, such that the user can implement software interlocks, calculations, etc.

h. Assign application programs to points (as opposed to assigning points to programs).

i. Obtain an "audit trail" of which application programs are controlling an individual point, on a point by point basis.

j. Create and/or modify DDC loops and parameters.

k. Create and/or modify override parameters.

l. Add, modify, and delete any applications program.

m. Add, delete, develop and/or modify custom dynamic color graphic displays utilizing either custom symbols or system supported library of symbols. Graphics shall support at least sixteen (16) colors and not less than sixty (60) outputs of real time, live dynamic data per graphic. The system shall allow this dynamic graphic data to be displayed as an animated symbol (i.e., when a pump starts the pipe fills up with water), an ASCII set (i.e., on-off), a decimal (i.e., 96.3F), or as an analog bar graph. Each operator work station shall support not less than 1,000 separate graphic pages. This contractor shall include fifteen (15) developed graphics as approved by the owner's representative for this project. The following graphic pages shall be provided as a minimum:

(1) Index page of all graphics, with direct selection
(2) Floor plan of each floor, with zone temperatures
(3) Schematic of each unique system, with values and status

n. Select a graphic screen refresh rate between 1 second refresh and 60 second

refresh rate.

4. Operator Work Station: Any operator work station shall:

   a. Accept data from the Controller LAN on an as needed basis without having to scan the entire network of DCUs or MCs for updated point data.

   b. Interrogate the Controller LAN for updated point data when requested by the system operator.

   c. Allow operator command of equipment connected to DCUs and MCs.

   d. Allow operator to place specific DCUs and MCs in or out of service.

   e. Allow parameter editing of DCUs, MCs, and "gateway" nodes (limited only by an individual operator's access assignments).

   f. Store duplicate data base on file for every DCU and MC and allow this data base to be downloaded to the remote panel while the system is on line.

   g. Control or modify specific programs on a per DCU, or MC basis.

   h. Develop, store and modify dynamic color graphics utilizing system supplied mouse and mouse supported software. It shall be possible for both mouse supported work stations and non-mouse supported work stations to coexist on the same Controller LAN.

   i. Provide data archiving of assigned points throughout the system and to support overlaid graphing of this data utilizing up to four (4) variables.

   j. To maintain system integrity, the operator shall have available an automatic DCU save utility. The database of the DCUs shall be automatically uploaded to a work station at 02:00 AM, for backup purposes. This utility will function for both direct connect and dial-up work stations.

   k. The FMS shall support not less than 15 operator work stations, each with simultaneous access to the Local Area Network. Regardless of how the operator work stations are connected to the Controller LAN (i.e., hardwired or via modem), the network shall support all specified functions.

5. Alarm Processing: The FMS shall have the following alarm processing features, all of which shall be owner definable through the input keyboard:

   a. Each off normal condition shall cause an alarm and an appropriate message, including the time of the alarm, system and point descriptor, alarm condition. The operator shall have the capability to select, at any time, which state/value shall be considered alarms and which alarms shall cause automatic dial-out to occur.

   b. Each critical alarm or change-of-state message shall be displayed. All Controller LAN network alarm messages shall be stored on disk and may be reviewed on the CRT and/or printed on operator selected printers at any time. It shall be possible to sort this alarm/change-of-state data base by date, time and/or item fields.

   c. An Alarm Summary shall show all new alarms and indicate which is the "best" graphic page to select to act upon the alarm condition. Each alarm shall have its “priority” listed and all alarms shall be displayed with highest priority first, then by reverse chronological order within a priority.

   d. Provide an automatic page selection option for alarms. This feature (operator activated) automatically selects and displays designated “best” graphic page for each alarm, even when the operator is signed off. In the event of multiple alarms, the page associated with the most recent highest

priority alarm is displayed.

e. Automatic user defined time delay of alarms during equipment start-up or shutdown shall be provided to prevent nuisance and false alarms.

f. Unique alarm delays on analog and discrete input points to prevent "flutter" alarms.

g. The operator shall have the capability to route specific alarms to specific work stations, and/or to specific pagers.

h. Unacknowledged alarms will continue to blink even if they have "returned to normal". Only operator acknowledgment can remove the blinking alarm indication. Red will signify points in alarm while green will signify points in normal condition.

i. Each operator work station will have the ability to notify an operator of an alarm condition in one or more points or controllers anywhere in the system. Alarm notification shall consist of:

(1) Automatic print of the alarm condition as described above.

(2) Display of an ICON indicating an alarm condition, including while in a third party program.

(3) Operator selectable audible alarm indication. The audible alarm may sound once, constant or not at all, at owners option.

(4) Relay operation at the PC workstation, used to activate notification devices where the operator will be too far from the PC to see visual indication, or the environment is too noisy to hear the PC's audible. Provide a strobe light for alarm indication for all PC workstations located in central plant areas.

6. Event Processing: The FMS software shall have the ability to automatically initiate commands, user-defined messages, take specific control actions or change control strategy and application programs as a result of an event condition.

a. An event condition may be an analog high or low value crossing an operator defined limit, a change-of-state, a specified state, or alarm occurrence, a return to normal or logical combinations of the above. Events shall not be limited to alarm occurrences only but shall also include time, dates, as specified system results. All event assignments or modifications shall be owner defined through the input keyboard.

7. Automatic Restart: The DCU shall include a software program to automatically restart field equipment on a restoration of power following a DCU power failure.

a. An owner defined time delay between individual equipment restart shall be provided. In addition, the software program shall allow equipment to be energized or de-energized based upon the time of day start/stop program in effect at the time of power restoration at the DCU.

8. Messages: The system shall be capable of automatically displaying or printing a user-defined message subsequent to the occurrence of selected events. Events shall not be limited to alarm occurrences. It shall be possible for the owner to construct independent messages for each DCU, each with as many as 60 characters. The operator shall be able to:

a. Compose, change, or delete any message

b. Display or log any message at any time

c. Assign any message to any event

9. Free Form Historical Reports: An operator shall be able to manually request reports from a console keyboard. All reports shall have time and date and shall not be limited to "canned" or "standard" format. Data shall be gathered from the field LAN's automatically and archived on owner selected work stations. The systems shall include a report writer function which supports as a minimum the following functions:

   a. Long term data archiving to hard disk

   b. Automatic directives to download to transportable media such as floppy diskettes or tapes for storage

   c. Data selection methods to include data base searches, sorts, and manipulation

   d. Data extraction shall support mathematical manipulation

   e. Data reports shall allow development of XY curve plotting, tabular reports (both statistical and summary),and multi-point timed based plots with not less than four (4) variables displayed.

   f. Generating reports either normally at operator direction, or automatically under PC directions. Both Event driven and scheduled automatic reports shall be supported.

10. Prepared Historical Report: Provide an on-line, historical, database sort report utility, with the following features:

    a. Prompts to select data base sort by time, by date, by point (or range of points) with system supplied default values of 24 hours, today, all Controller LAN points, respectively.

    b. Prompts for activating "conditional" sorts, including: changes-of-state, alarms, returns to normal, operator sign on/off, operator acknowledgments, command errors, program control of a point, test on/off, manual on/off, program control (ATC, Demand, Event) override, power restore, LAN reconfiguration, controller off line, time/date modifications, and archive disk memory 90% full, 95% full, and full.

    c. Provide audit trail messages of operator edits of access control, specifically editing the databases for individuals, groups, tenants, transactions, doors, personnel schedules, access initiated control, and elevator control. Also, include door prop alarms, forced door alarms, and failure of the database to download to field controllers.

    d. Single keystroke retrieval resulting in a report listing the most recent condition first, along with the time, date, address, name, condition type, and value.

11. Parameter Save/Restore: The most current operating system including the most current parameter changes and modifications will be stored on disk or diskette.

12. Data Collection: The operator work station shall have the ability to automatically

collect and store in disk files the following information:

a. Daily KWH consumption, peak demand, and time of peak demand for up to 32 KWH meters over a 2-year period.

b. Daily consumption for up to 30 meters over a 2-year period.

c. Daily billable exclusive and shared override KWH consumption and billable override time as well as non-billable exclusive and shared override KWH and non-billable override time for up to 1024 zones over a 10-year period.

d. Provide archiving of stored data for use with system supplied custom reports, (i.e., it shall be possible to request the status of a temperature between 10/1/95 and 10/3/95 on an hourly basis).

13. Archiving to disk shall automatically occur as long as the PC work station is ON and physically capable of communicating with the Controller LAN(s), regardless of what programs are currently being executed at the time data is needed to be stored to disk (i.e., an operator can be developing a financial spread sheet in LOTUS™ when the FMS stores field trending information to disk--the current LOTUS™ program shall not be interrupted or halted) for archiving.

14. Graphic Display: On-line graphic development shall be supported on all work stations connected to the LAN either as "hard-wired" direct connect or via remote dial-in. The system shall support any mix of mouse supported work stations or non-mouse work stations.

15. The systems graphic software shall provide the following minimum features:

a. "Page Linking" such that it is possible to "zoom" into a specific AHU or any other page through a sequence of graphics without using anything but the system mouse.

b. Generate, store, and retrieve library symbols for use in generating graphic pages.

c. Single or double height characters.

d. Sixty (60) dynamic points of data per graphic page.

e. Pixel level resolution. Graphics will be displayed on VGA monitors with a 640 X 480 resolution, minimum. Color selections will be made from a color bar consisting of 16 colors, with adjacent text description.

f. Animated objects for discrete points (i.e., when a pump starts, the pipe fills with water or when a damper shuts it goes closed on the screen).

g. Analog bar graphs for analog points. The operator shall be able to locate up to 60 bar graphs per graphic page, with options as to bar graph color, dimensions, horizontal/vertical orientation, and limit values.

h. The real time value of each input or output from the DCU's DDC control block modules shall be displayable on the color graphic.

i. An on-line "Draw" utility with a "toolkit" containing the following:

(1) Library Symbols
(2) Fill
(3) Page Links
(4) Line
(5) Undo
(6) Point Values
(7) Box
(8) Move

(9) Line Values
(10) Circle
(11) Delete
(12) Arc

j. Provide for import of .PCX file format graphics developed in third party programs such as Paintbrush. Such imported graphics shall be used as a "backdrop", so that all other dynamic and animated system features may be superimposed on this graphic. Similarly, it shall be possible to import CAD type drawings, by first converting the CAD drawing from .DXF format to .PCX format.

16. Maintenance Management: Each DCU, acting in conjunction with the operator work station's graphic displays, shall support a maintenance management program on all specified points. This program as a minimum shall provide the following:

a. Discrete run time monitoring on per point basis. Run time shall be able to be accumulated on two basis - since the beginning of time, and since last reset.

b. Maintenance scheduling targets on specific equipment with auto annunciation, auto scheduling and auto shutdown.

c. Equipment safety targets which generate an alarm or user defined message if the equipment has not been serviced and cleared in time. The program shall also allow automatic shut down of the equipment if the safety limit is exceeded.

d. CRT display of maintenance material needed including estimated labor.

e.f. Single command reset on a per point basis.

17. Context Sensitive Help Screens: Provide a dedicated function key which will call up a context sensitive help screen associated with the current keyboard/mouse input.

18. Application Sensitive Help Screens: Provide the capability to develop help screens tailored to job specific applications. These screens shall be displayed by selecting an Icon from an associated graphic display.

19. Dedicated Function Keys: The system shall include the following dedicated function keys as a minimum:

a. Function Key Help - definition of all function keys.

b. System Help - context sensitive Help

c. Silence - silences new audible alarms

d. Recall - re-enters deleted data during editing

e. Alarm Summary - displays alarm summary screen to review or acknowledge alarms

f. Messages Summary - displays events screen to review or acknowledge system messages

g. Transactions Summary - displays access control activity

h. Page Acknowledge - allows acknowledgment of all alarms that appear on a System Page, DCU Summary, Page Summary, or Alarm Summary

20. Transactions Summary: Provide password protected access to historical files containing Access Control related transactions. The Transactions Summaries shall

be based on user defined “filters” to the Access Control database. The filters shall operate over user defined time ranges for time and date, using a two entry (earliest, latest) selection for both time and date to support multiple days, each with a time slice, versus a continuous duration between two days. The operator shall be able to establish an unlimited quantity of custom “filters”, on line. In addition to providing an “all transactions” filter, provide an operator definable custom filter template with the following entries:

a. Filter Name (up to 16 characters)

b. Point Address - Doors shall be points in the system. Provide two Door Points which define the low and high end of a range of Doors

c. Tenant - Provide two Tenant numbers which define the low and high end of a range of Tenants (1-255)

d. Key/Card - Provide two ID numbers which define the low and high end of a range of ID numbers (1-24,000)

e. Zone - Provide two anti-passback zones which define the low and high end of a range of anti-passback zones (0-31)

f. Records Display type: Permanent/Temporary/Both as defined in the Individuals Editor.

g. Device Name: 16 character Door or Elevator cab name. May be used as an alternative to the Point address range above, for operator convenience.

h. Group Name

i. Last Name

j. First Name

k. Field Names: Provide a separate entry for each of the 1 to 16 user defined fields. These fields may have from 1 to 16 ASCII text characters, as well as the wild card ? and * symbols for matching and sorting on subsets of a field.

l. Transaction Selection: Operator shall be able to select from any or all of the following: Reader entry, Reader entry-elevator, Reader exit, Denied - schedule, Denied - APB, Denied - tenant, Denied - Issue, Denied - selection.

(1) Provide a print utility for the transactions summary, which includes the following statistics at the end of the report:

(a) Reader entries for selected readers (excludes elevators)

(b) Elevator entries for selected readers

(c) Reader exits for selected readers

(d) Reader denials (based on Tenant, issue, selection, schedule, or APB)

(2) Provide a Roll Call Report which shall produce a list of all entries without a corresponding exit. This report shall prompt for the earliest date and the earliest time, with a default of “today’.

2.27 DCU/MCI APPLICATION ROUTINES: A DCU shall include various software packages, each of which performs a specialized application routine. All of the application routines listed shall be interactive, compatible with and capable of global operation as necessary. The use of any application

routine shall not cause any other software to malfunction.

A. Demand Monitoring and Load Shedding: (Available not used) Each DCU supports a program designed to control the electrical "demand" due to peaks in electrical energy consumption.

1. The Demand program shall operate in a global fashion and shall be able to control outputs in any DCU or MC to maintain the Demand setpoint, regardless of which panel the meter is connected to. Systems using a demand program that does not operate in a global fashion are unacceptable under this specification. Systems containing multiple Controller LANs shall have this global function occur between LANs as well.

2. The input to this program shall be a pulse count from the incoming power meter connected directly to a pulse accumulator in a DCU.

3. Forecast demand (KW) shall be predicted by the sliding window method.

4. The system shall provide a minimum of 3 demand targets per demand meter. The system shall automatically change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.

5. Each load shall not only be assigned a load shed priority, but will be assigned a minimum "ON" time and a maximum "OFF" time. All loads in any one priority level will be shed before loads of the next priority level will be shed. Loads will be shed and restored on a "round-robin" basis. All parameters shall be operator selectable and displayable via the CRT. The system shall provide for a minimum of seven priority levels.

a. Equipment connected to Micro Controllers (MCs) will have their occupied deadbands widened in lieu of shedding the loads.

6. Demand forecasting shall be by the "sliding window" technique. "Ideal rate", "instantaneous" or other non-forecasting demand programs using analog values for KW are not acceptable under this specification.

7. To avoid overcorrection (oscillation) by shedding and restoring loads for minor perturbations, a control band (upper and lower limit) shall be included so that the load will be shed when the upper limit is exceeded, and restored when the lower limit is reached.

8. A printed message shall be generated when the demand target upper limit is exceeded and all priority loads have been shed. The demand exceeded alarm will also show on the CRT.

9. Maximum demand and its time of occurrence, and energy consumption for the day shall be stored at midnight. Monthly consumption shall be stored and reset on a user selected day.

B. Automatic Time Scheduling (ATS): Each DCU/MCI shall provide self-contained ATS programs for automatic start/stop/scheduling of building loads. Each ATS program shall support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules. The special days schedule shall support up to 30 unique date/duration combinations. Each load shall support an individual time program, as a minimum.

1. Each load shall be able to be assigned at least 16 control actions per day with 1 minute resolution. Operator selectable time schedule operation choices shall include the following: Start, Optimized Start, Stop, Optimized Stop, Cycle, Optimized Cycle.

2. A minimum of 30 holiday periods up to 99 days in length may be specified for the year.

3. It shall be possible to create "temporary" schedules up to a week in advance that will be in operation only on the day or days specified.

4. Support a temporary "special day" date and duration to be broadcast to selected or all sites to account for unusual situations Such as temporary operating hours or "snow days".

5. In addition to individual load scheduling, provide for group scheduling by designating equipment to be linked to a "master" time schedule, for quick schedule changes of large groups of equipment which follow a common schedule. The master schedule shall provide a choice of fixed start and stop times by day, or plus and minus adjustments to the existing schedule, in minutes. Master schedules shall provide a choice of immediate activation or activation at a later date and time.

6. Support control actions to be performed at any operator selectable time of day as well as at "sunrise" and "sunset". Sunrise and sunset parameters shall be selectable based on time zone, latitude, and longitude.

C. "Distributed" Start/Stop Time Optimization (SSTO): Each controlled point shall include an adaptive, self learning, software program to perform optimized start-up and/or shutdown of selected equipment. The SSTO program shall start HVAC equipment at the latest possible time and still allow the equipment to achieve the desired zone conditions by occupancy time. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.

1. The SSTO program shall perform optimized start/stop as a function of outside conditions and individual inside conditions. The SSTO program shall be adaptive, self-tuning with the capability to adjust to changing conditions unattended. Systems using global optimization based on "representative" inside conditions are not acceptable.

2. The system operator shall be able to, for each point under control of the SSTO program, establish and modify the following parameters:

   a. The occupancy period

   b. The desired temperature at the beginning of the occupancy period

   c. The desired temperature at the end of the occupancy period

   d. The maximum earliest start allowed prior to the scheduled start of the occupancy period. The actual system calculated time to start shall be displayable as a system value.

3. The Central Plant shall be started as the result of the first zone being activated by its distributed SSTO program - not by a separate time based or optimized program.

D. Duty Cycle Control (DCC): (not used) Each DCU shall include a software program to perform Temperature Compensated Duty Cycle Control. The DCC program shall periodically stop and start loads, based on space temperature, and according to various On/Off patterns. This temperature compensation consists of modifying the off portion of the cycle based on operator specified comfort parameters. The total cycle time shall be maintained by increasing the on portion of the cycle by the same amount that the off portion is reduced. The result should be a net reduction in both the electrical demand and the energy consumed. The FMS operator shall be able to set and modify the following parameters for each individual load.

1. Minimum and maximum Off time
2. On/Off time in one minute increments
3. Time period from beginning of interval until load can be cycled
4. Manually override the DCC program and place a load in an On or Off state
5. Cooling Target Temperature (degs.) and Differential
6. Heating Target Temperature (degs.) and Differential
7. Cycle off adjustment (min./deg.) for both cooling and heating target temperatures.

E. Night Setback/Setup Program: Each DCU and MC shall provide software to automatically reduce the heating space temperature setpoint or raise the cooling space temperature setpoint during unoccupied hours. The night setback program shall be operated in conjunction and coordinated with the scheduled start/stop and optimum start/stop programs.

F. Calculated Points: Each DCU/MCI shall provide the operator a means of defining calculations and totalization computed from monitored points (analog/digital points), constants, or other calculated points. Calculations shall be executed at the uniquely assigned point scan rates.

1. The operator shall be able to employ any of the following arithmetic, algebraic, Boolean and special function operations to define the computation:

a. add
b. square root
c. greater than
d. subtract
e. and
f. less than
g. multiply
h. or
i. equals
j. divide
k. not
l. not equal
m. negate
n. month
o. greater than or equal to
p. day
q. year
r. less than or equal to
s. minute
t. hour
u. minutes past midnight
v. day of week
w. exclusive or
x. enthalpy
y. dewpoint
z. relative humidity

2. Numeric values generated from the calculations shall be treated like any other analog value in that alarm limits may be assigned to them. These values may be used in any DCU/MCI on the controller LAN for any function that a "hardwired point" might be used (i.e., control sequences, setpoints, targets, etc.).

G. Event Initiated Programming (EIP): Each DCU/MCI shall provide event initiated programs. An event may be initiated by any data point. Triggering an EIP shall cause a series of control actions in a sequence, i.e., if point A reaches a Hi alarm, start pumps 1 through 12. Up to 25 sequences can be defined. Each sequence may cause up to 16 control actions. Sequences may be chained together.

1. The time interval between each control action shall be operator definable from between 0 to 3600 seconds. Each motor may lock out associated analog alarms when the motor is Off by programming each desired analog point for alarm disable.

2. The output of a sequence may be an analog value.

3. The programming shall provide for "skip" logic without requiring any programming code or machine type language input.

4. The system shall have the ability to verify completion of one action before

proceeding to the next sequential action. If proper states are not verified the EIP shall be able to skip to an operator specified next action.

H. Direct Digital Control (DDC) Modules: Each DCU shall provide "Block" or "Modular" programming software so that the operator can easily develop custom control strategies and sequences of operation, without learning a programming language.

1. Control loops and sequences shall be defined using "modules" that are analogous to traditional pneumatic or electric control devices. Modules may be linked together to form more complex control strategies. The use of mathematical equations, "BASIC", or proprietary programming languages for defining a DDC control loop is unacceptable.

2. The following types of modules shall be supported in firmware for each DCU in the system:

a. PID controller with analog output or PWM output

b. PID controller with floating (paired) output

c. Two-position controller

d. Primary and secondary reset schedule selector

e. Hi/Low signal selector

f. Single pole double throw relay

g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities

3. Should a sensor fail or be taken out of service, the DDC program shall execute a user defined fail-safe output.

4. The value or state of each of the lines which interconnect DDC modules shall be displayable on the CRT graphic pages to allow logic diagrams of the DDC strategies to be shown with actual values.

I. Self Tuning PID Loops: Three methods of tuning PID Loops shall be available: Manual, Automatic, and Adaptive. To assist the operator in tuning a DCU with Direct Digital Control PID or floating loops, a "tuning" utility shall be provided that will allow the collection of data and tuning of the process in real time.

1. The tuning utility shall display the following information on the CRT upon operator request:

a. Control loop being tuned
b. Input (process) variable
c. Output (control) variable
d. Setpoint of loop
e. Proportional band
f. Integral (reset) Interval
g. Derivative (rate) Interval

2. The above information shall be displayed on any PC work station CRT in a graphical format with automatic scaling such that the input and output variable are superimposed on a graph of "time" vs. "variable". This program shall allow the operator to affect the output variable by modifying the setpoint, gain, etc., and view the results on the display. In addition to viewing the results on the CRT, it shall be possible to print the module parameters being tuned with the graph while it is being tuned.

3. Automatic Tuning - Provide DCUs with an on-line utility which may be manually turned on to "disturb" the process. This utility shall then monitor the results and

calculate new parameters for sample interval, Proportional gain, Integral gain, and Derivative gain. This utility shall be usable during the commissioning process to establish reasonable values, then turned off.

4. Adaptive Tuning - Provide DCUs with an on-line utility which may run continuously. Adaptive tuning shall be initiated automatically whenever an operator defined change in the process (input) variable is detected. This utility shall monitor the process (control loop) after a natural disturbance, and automatically recalculate the Proportional gain, Integral gain, and Derivative gain. This utility shall be used to keep a system tuned, as the equipment ages and occupancy and loads change, after commissioning.

5. Self Tuning Parameters - Provide the following operator selectable self tuning parameters to support automatic and adaptive tuning:

   a. Adaptive control enabling point - the system point whose status determines whether adaptive control is enabled or disabled.

   b. Maximum bump - output step change required to produce a change in the input, greater than the noise level, but not so great as to damage equipment.

   c. Settling time - the time it takes the PID input (process variable) to settle down after a process disturbance. For automatic tuning, the time interval between setting the PID output to the control point and the beginning of the tuning cycle. For adaptive tuning, the minimum time that will be observed between parameter calculations.

   d. Maximum overshoot - percent allowed

   e. Target damping - the desired reduction in the process variable overshoot from the first overshoot (maximum overshoot) to the second, in percent.

   f. Noise band - the minimum process variable perturbation that will initiate an adaptive calculation of the PID parameters, in percent of the input range.

J. Trend Logging: Each DCU/MCI in the system shall contain a trending program that will store samples of all of the DCU/MCI data points. The trend log file will be updated in memory continuously at discretely assignable intervals by the trend program. As the DCU/MCI data files begin to fill, the DCU/MCI shall have the capability to automatically initiate an upload request and shall then store the data on hard disk for future use. The trending program may also be "time synchronized" to start sampling at an operator specified time each day and cease sampling at operator specified end times. The sampling on the trend interval established by the operator shall allow sample resolution of one minute. Sampling shall allow co-ordination with the "on" state of a specified point, i.e., sample when "on", cease to sample when "off".

1. It shall be possible to display the trend samples for each DCU/MCI in the system from the operator's work station in a graphic format. The trend graph shall be automatically scaled and shall display at least 60 samples of data in a plot of time vs. data on the operator work station. It shall be possible to print the graph at any time while being displayed on the CRT.

2. A system-wide twelve point trend log shall be available. This trend log shall support operator selected sample intervals, print intervals, print start times, and print stop times.

K. Override: It shall be possible to override the normal schedules of the equipment being controlled on the Controller LAN and, if required, the actual control sequences.

1. The override shall be initiated by all of the following:

a. A touch tone phone through interactive digital voice prompts
b. Local console
c. Operator PC work station

2. The touch-tone telephone interface unit shall be controller LAN resident and support network wide after hours billing. The touch-tone telephone interface unit shall support up to 50 zones of control, linking up to 100 discrete system points, and shall have the ability to generate after hour bills based on both shared and common loads. Additional system access codes shall be provided for these specialized functions:

a. After hours maintenance for non-billable overrides.
b. Supervisor for acquiring any point information.
c. Manager for acquiring any point information and controlling any point.

3. For each zone, the following values must be stored on a daily basis:

a. Non-billable exclusive KWH override.
b. Non-billable shared KWH override.
c. Non-billable override time.
d. Billable exclusive KWH override.
e. Billable shared KWH override.
f. Billable override time.

4. When local LAN access is by way of a touch-tone telephone, the LAN shall provide for digitized voice communication with the operator to include data exchange like temperatures, zone status, override condition, programmed times, etc.

L. Access Initiated Control: Provide a means to control the state of a Discrete Output point, based on the condition (entry, exit, denial) produced when specific ID devices or user defined list of ID devices are presented to a reader or user defined list of readers. This assignment shall be available to the user by individual ID numbers and doors as well as by "groups". Support the ability to trigger multiple events from a single Access Initiated Control (AIC) sequence. AIC sequences shall be user configurable. Support the ability for the user to automatically change the state of a DO point (both start and stop actions) based on the following:

1. Reader entry
2. Reader entry-elevator
3. Reader exit
4. Denied entry-schedule
5. Denied exit-schedule
6. Denied entry-APB
7. Denied entry-issue
8. Denied exit-issue
9. Denied entry-selection
10. Denied exit-selection

PART III - EXECUTION

3.01 COMPLETE SYSTEM:

A. Install a complete system with an overall ATC controller, with Central Direct Digital Controller(s) for central fan systems and related functions, with blower coil unit controls and related functions, with portable handheld programmer for blower coil unit box control, with all power and communications wiring, with sensors, room thermostats, actuators, valves, dampers, etc.

3.02 CONTROL SEQUENCES:

A. The sequences of control for the DDC system shall be equivalent to those specified with the

added benefits of programmable algorithmic control.

B. Fully describe the sequences in the submittals.

3.03 Fully document all work by shop drawing and product bulletin submittal, work from reviewed drawings, maintain record documents during installation, provide a complete record drawing document set at completion.

3.04 SYSTEM ACCEPTANCE:

A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

B. Field Equipment Test Procedures: DDC controls panels shall be demonstrated via a functional end to end test. Such that:

1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operations verified.

2. All analog input channels shall be verified for proper operation.

3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displaying value.

4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.

5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.

6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

C. Workstation Test Procedures: The system workstation test procedures shall be as follows:

1. Communication with each DDC control panel shall be demonstrated.

2. Operator commands will be explained and demonstrated.

3. Control sequences shall be demonstrated for proper operation.

4. All available system reports and logs shall be demonstrated at the system workstation.

5. Correct system start-up and shutdown procedures shall be demonstrated.
6. All controllers shall be demonstrated to operate in a standalone mode.

D. Record Drawing Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply "6" complete 11x17 as-built drawing sets, together with AutoCad diskettes to the Contracting Officer.

E. Operation and Maintenance Manuals: Submit required copies of operation and maintenance manuals. See Section 230100. Include the following:

1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.

2. An operator's manual which will include detailed instructions for all operations of the system.

3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.

4. A programmer's manual which will include all information necessary to perform programming functions.

5. A language manual which will include a detailed description of the language used and all routines used by the system.

6. Flow charts of the control software programs utilized in the DDC system.

7. Flow charts of the custom software programs utilized in the DDC system as approved.

8. Complete program listing file and parameter listing file for all programs.

9. A copy of the warranty.

10. Operating and maintenance cautions and instructions.

11. Recommended spare parts list.

3.05 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230923

SECTION 230933 - ELECTRIC CONTROL SYSTEMS

PART I - GENERAL:

1.1 RELATED DOCUMENTS: See Division 15 - "Mechanical Control Systems".

1.2 SUMMARY:

A. Electric control functions and systems indicated on the drawings and specified herein.

B. Complete interrelationships with pneumatic-control systems, automation systems and mechanical equipment.

1.3 QUALITY ASSURANCE: See Division 15 - "Mechanical Control Systems".

1.4 SUBMITTALS: See Division 15 - "Mechanical Control Systems".

1.5 DELIVERY, STORAGE AND HANDLING: See Division 15 - "Mechanical Control Systems".

1.6 INSTRUCTION OF OWNER'S PERSONNEL: See Division 15 - "Mechanical Control Systems".

PART II - MATERIALS AND METHODS

2.1 ELECTRICAL POWER SUPPLY:

A. Obtain power from existing Division 16 panel. Furnish appropriate circuit breakers and extend conduit and wiring assigned to this division.

B. Furnish and install UL listed voltage reducing transformers required for this work. Size transformers to see no more than 70 percent of rated capacity at full load.

C. Make all electrical installations in conformance with the National Electrical Code (current edition) and in accordance with Division 16.

D. Use same product lines for similar devices as used by Division 16000 to result in a coherent project.

E. Control Wiring

1. In all building areas, i.e. electrical rooms, mechanical rooms, boiler rooms, above ceilings, within walls, etc., all control wiring shall be installed in conduit per National Electric Code. Installation shall be square with the walls of the buildings.

2. Number and code all wiring.

F. Use no wire smaller than 12 gauge, no conduit smaller than 3/4".

2.2 ELECTRIC THERMOSTATS: Wall-mounted, line voltage. For loads above device rating, use control circuit with auxiliary relay switching.

2.3 SMOKE DETECTORS: For installation in all fan systems above 2,000 cfm, systems 15,000 cfm and larger require two such, one in return, one in supply air. Furnished by Division 26000, installed by this Division, Power and fire alarm wiring by Division 16000, control circuit alarm contact by this Division.

2.4 FREEZESTATS: Manual reset, non-averaging, extended capillary tubes. Honeywell L-480G, Johnson A11A-I/A70HA-1. Penetrate plenum wall with grommet protection, support capillary on 1/4" copper tubing. use DPDT action as needed or auxiliary relays with powered circuits.

2.5 AUXILIARY RELAYS:

Light Duty - as required.

Heavy Duty - Square D, Class 8501, Type X.

T-E, S & S.

2.6 PRESSURE SWITCH FOR DIRTY FILTER INDICATION:

.05-12" wg adjustable Dwyer 1630.

Johnson P-32.

PART III - INSTALLATION

3.1 CLEANING AND LUBRICATION: See Division 23 - "Mechanical Control Systems".

3.2 TESTING AND ADJUSTING OF SYSTEM: See Division 23 - "Mechanical Control Systems".

PART IV – EXECUTION

4.1 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 15965

SECTION 231123 - NATURAL GAS PIPING

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specifications sections, apply to work of this section.

B. Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 DESCRIPTION OF WORK:

A. Extent of natural gas systems work is indicated on drawings and schedules, and by requirements of this section.

B. Trenching and backfill required in conjunction with gas service piping is specified in applicable Division-23 sections, and is included as work of this section.

1.3 QUALITY ASSURANCE:

A. MANUFACTURER'S QUALIFICATIONS: Firms regularly engaged in manufacture of natural gas systems products, of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. INSTALLER'S QUALIFICATIONS: Firm with at least 3 years of successful installation experience on projects with natural gas systems work similar to that required for project.

C. CODES AND STANDARDS:

1. NFPA Compliance: Fabricate and install natural gas systems in accordance with NFPA 54 "National Fuel Gas Code".

2. Utility Compliance: Fabricate and install natural gas systems in accordance with Questar Gas Company regulations and recommended practice.

3. IFGC Compliance: Fabricate and install natural gas systems in accordance with ICC "International Fuel Gas Code".

1.4 SUBMITTALS:

A. PRODUCT DATA: Submit manufacturer's technical product data and installation instructions for natural gas systems materials and products.

B. SHOP DRAWINGS: Submit scaled layout drawings of natural gas pipe systems including, but not necessarily limited to, pipe and tube sizes, location, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Include schematic diagrams of each gas train. Indicate interface and spatial relationship between piping and proximate equipment.

C. RECORD DRAWINGS: At project closeout, submit record drawings of installed natural gas systems piping and products, in accordance with requirements of Division 1.

D. MAINTENANCE DATA: Submit maintenance data and parts lists for natural gas systems materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Division 1.

PART II - PRODUCTS

2.1 MATERIALS AND PRODUCTS:

A. GENERAL: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with NFPA 54 where applicable, base pressure rating on natural gas piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials use in natural gas systems. Where more than one type of materials or products are indicated, selection is Installer's option.

2.2 BASIC IDENTIFICATION:

A. GENERAL: Provide identification complying with Division-15 Basic Mechanical Materials and Methods section "Mechanical Identification", in accordance with the following listing:

1. Building Distribution Piping: Plastic pipe markers.

2. Gas Service: Underground-type plastic line markers.

3. Gas Valves: Plastic valve tags.

2.3 BASIC PIPES AND PIPE FITTINGS:

A. General: Provide pipes and pipe fittings complying with Division-15 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings", in accordance with the following listing:

B. UNDERGROUND GAS SERVICE PIPING:

1. All Pipe Sizes: Black steel pipe; Schedule 40; wrought-steel buttwelding fittings.

2. Wrapping: Machine wrap pipe using 50% overlap wrap, with polyvinyl chloride tape. Hand wrap fittings using 100% overlap wrap extending 6" beyond fitting onto wrapped pipe. Comply with tape manufacturer's installation instructions.

3. Pipe Sizes 1/2" Through 12": Thermoplastic gas pressure pipe, tubing, and fittings complying with ASTM D 2513.

C. BUILDING DISTRIBUTION PIPING:

1. Pipe Size 2" and Smaller: Black steel pipe; Schedule 40; malleable-iron threaded fittings (exposed), welded fittings and joints (concealed).

2. Pipe Size 2-1/2" and Larger: Black steel pipe; Schedule 40; wrought-steel buttwelding fittings.

2.4 BASIC PIPING SPECIALTIES:

A. GENERAL: Provide piping specialties complying with Division-15 Basic Mechanical Materials and Methods section "Piping Specialties", in accordance with the following listing:

1. Pipe escutcheons.
2. Vandal-proof vent caps.

3. Dielectric unions.
4. Pipe sleeves.
5. Sleeve seals.

2.5 BASIC SUPPORTS AND ANCHORS:

A. GENERAL: Provide supports and anchors complying with Division-15 Basic Mechanical Materials and Methods section "Supports, and Anchors", in accordance with the following listing:

1. Adjustable swivel pipe rings for horizontal-piping hangers and supports.

2. Two-bolt riser for vertical piping supports.

3. Concrete inserts, C-clamps, and steel brackets for building attachments.

2.6 SPECIAL VALVES:

A. GENERAL: Special valves required for natural gas systems include the following types:

1. Gas Cocks:

a. Gas Cocks 2" and Smaller: 150 psi non-shock WOG, bronze straightway cock, flat or square head, threaded ends.

b. Gas Cocks 2-1/2" and Larger: 125 psi non-shock WOG, iron body bronze mounted, straightway cock, square head, flanged ends.

B. MANUFACTURER: Subject to compliance with requirements, provide gas cocks of one of the following:

1. DeZurik Corp.
2. Jenkins Bros.
3. Lukenheimer Co.
4. NIBCO, Inc.
5. Powell (The Wm.) Co.
6. Rockwell International; Flow Control Div.
7. Stockham Valves and Fittings.
8. Walworth Co.

2.7 PRESSURE REGULATING VALVES:

A. GENERAL: Provide single stage, steel jacketed, corrosion- resistant gas pressure regulators; with atmospheric vent, elevation compensator; with threaded ends for 2" and smaller, flanged ends for 2-1/2" and larger; for inlet and outlet gas pressures, specific gravity, and volume flow indicated.

2.8 GAS METER: By Questar Gas Company. Contractor to coordinate and pay all associated fees with gas meter set and supply line to the buildings.

PART III - EXECUTION

3.1 INSPECTION:

A. GENERAL: Examine areas and conditions under which natural gas systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASIC IDENTIFICATION:

A. GENERAL: Install mechanical identification in accordance with Division-15 Basic Mechanical Materials and Methods section "Mechanical Identification".

3.3 INSTALLATION OF NATURAL GAS PIPING:

A. GENERAL: Install natural gas piping in accordance with Division-15 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

B. Use sealants on metal gas piping threads which are chemically resistant to natural gas. Use sealants sparingly, and apply to only male threads of metal joints.

C. Remove cutting and threading burrs before assembling piping.

D. Do not install defective piping or fittings. Do not use pipe with threads which are chipped, stripped or damaged.

E. Plug each gas outlet, including valves, with threaded plug or cap immediately after installation and retain until continuing piping, or equipment connection are completed.

F. Install drip-legs in gas piping where indicated, and where required by code or regulation.

G. Install "Tee" fitting with bottom outlet plugged or capped, at bottom of pipe risers.

H. Use dielectric unions where dissimilar metals are joined together.

I. Install piping with 1/64" per foot (1/8%) downward slope in direction of flow.

J. Install piping parallel to other piping, but maintain minimum of 12" clearance between gas piping and steam or hydronic piping above 200^{o}F (93^{o}C).

K. For piping underground beneath buildings, install in welded conduit. Extend conduit inside and terminate in accessible portion of building and seal. Extend conduit outside minimum of 4" from building, and vent above grade.

L. For piping running through ducts or air plenums, install in welded conduit, ventilated on both ends.

M. For risers running through concrete or asphalt, install through minimum 6" pipe sleeve. Fill annular space with gravel.

N. Install magnesium anodes for underground steel pipe, one 5-lb anode for up to 100' in length and one 5-lb anode for each additional 100'.

O. Install magnesium anodes for each underground steel or malleable- iron fitting, isolated between 2 sections of plastic pipe; one 3- lb anode for each fitting.

3.4 GAS SERVICE:

A. GENERAL: Arrange with Mountain Fuel Supply Company to provide gas service to indicated location with shutoff at terminus. Consult with Utility as to extent of it's work, costs, fees and permits involved. Pay such costs and fees; obtain permits.

B. Extend service pipe from Utility's terminus to inside building wall, under Utility's direction.

3.5 INSTALLATION OF PIPING SPECIALTIES:

A. Install piping specialties in accordance with Division-15 Basic Mechanical Materials and Methods section "Piping Specialties".

3.6 INSTALLATION OF SUPPORTS AND ANCHORS:

A. Install supports and anchors in accordance with Division-15 Basic Mechanical Materials and Methods section "Supports and Anchors".

3.7 INSTALLATION OF VALVES:

A. GAS COCKS: Provide at connection to gas train for each gas-fired equipment item; and on risers and branches where indicated.

B. Locate gas cocks where easily accessible, and where they will be protected from possible injury.

C. Control Valves: Install as indicated. Refer to Division 16 for wiring; not work of this section.

D. PRESSURE REGULATING VALVES: Install as indicated; comply with Utility requirements. Pipe atmospheric vent to outdoors, full size of outlet. Install gas shutoff valve upstream of each pressure regulating valve.

3.8 EQUIPMENT CONNECTIONS:

A. GENERAL: Connect gas piping to each gas-fired equipment item, with drip leg and shutoff gas cock. Comply with equipment manufacturer's instructions.

3.9 FIELD QUALITY CONTROL:

A. PIPING TESTS: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.

3.10 ADJUSTING AND CLEANING:

A. CLEANING AND INSPECTING: Clean and inspect natural gas systems in accordance with requirements of Division-15 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

3.11 SPARE PARTS:

A. VALVE WRENCHES: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

3.12 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 231123

SECTION 232113 - GENERAL PIPES AND FITTINGS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. This section is Division 232113 General Pipes and Fittings section, and is part of each Division 23 section making reference to pipes and pipe fittings specified herein.

C. Division 230000 General Mechanical Requirements apply to work of this section.

1.2 SUMMARY:

A. This section is generic in that it describes material and installation required by several other sections of this specification.

B. Types of pipes and pipe fittings specified in this section include the following:

1. Steel Piping
2. Copper Piping
3. Cast-Iron Pressure Piping
4. Cast-Iron Soil Piping
5. Grooved Joint Piping
6. Miscellaneous Piping Materials/Products.

C. Pipes and pipe fittings furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications:

1. Firm with at least three years history of successful experience on projects of similar nature.

2. Licensed as a firm in the contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the contractor.

4. All workmen employed on the project to carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

C. Welding Certification:

1. Each welder shall have passed a qualification test within the past six months prior to working on the project.

2. The test shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, "Welding Qualifications", ASME Section VIII, and ANSI 313.

3. The test report shall certify that the welder is qualified to weld the material to be used at the job site in the positions required (flat, verticle, overhead etc).

4. Submit three copies of each welder's qualification test report to the Project Manager for approval prior to commencing the work. No welder shall be used on the project until so certified.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing manufacturer, pipe or tube weight, fitting type, and joint type for each piping system.

B. Welding Certifications: Submit reports as required for piping work.

C. Brazing Certifications: Submit reports as required for piping work.

D. Maintenance Data: Submit maintenance data and parts lists for each type of mechanical fitting. Include this data, product data, and certifications in maintenance manual; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes And Standards:

1. Welding: Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9, as applicable, for shop and project site welding of piping work.

2. Brazing: Certify brazing procedures, brazers, and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

3. NSF Labels: Where plastic piping is indicated to transport potable water, provide pipes and pipe fittings bearing approval label by National Sanitation Foundation (NSF).

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Store pipe in a manner to prevent sagging and bending.

B. Store pipe in a manner to prevent dirt and debris from entering piping. When possible store steel and copper pipes and tubing inside and protected from weather. Whether stored inside or outside elevate above grade and enclose with durable waterproof wrapping. Raise slightly one end of sealed piping to prevent accumulations of condensate and pitting where condensate accumulates.

C. Protect flanges and fittings from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART II - PRODUCTS

2.1 GENERAL:

A. Piping Materials: Provide pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards. Use United States (domestic) manufactured pipe only. Do not use foreign made pipe.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable. Use domestic manufactured fittings only. Do not use foreign manufactured fittings.

2.2 STEEL PIPES AND PIPE FITTINGS:

A. Black Steel Pipe: Seamless or ERW, ASTM A 53.

B. Galvanized Steel Pipe: ASTM A 53.

C. Galvanized Seamless Steel Pipe: ASTM A 53.

D. Electric-Resistance-Welded Steel Pipe: ASTM A 135.

E. Electric-Fusion-Welded Steel Pipe: ASTM A 671, A 672, or A 691.

F. Cast-Iron Flanged Fittings: ANSI B16.1, including bolting.

G. Cast-Iron Threaded Fittings: ANSI B16.4.

H. Malleable-Iron Threaded Fittings: ANSI B16.3; plain or galvanized as indicated.

I. Unions: ANSI B16.39; 300 lb. ground joint malleable iron, hexagonal, selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated.

J. Dielectric Unions: 175 psig WSP at 250^{o}F. Equal to Walter Vallet Company V-line insulating coupling.

K. Threaded Pipe Plugs: ANSI B16.14.

L. Steel Flanges/Fittings: ANSI B16.5, including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.

1. Material Group: Group 1.1.

2. End Connections: Buttwelding.

3. Facings: Raised-face.

4. Steel Pipe Flanges For Waterworks Service: AWWA C207.

M. Forged-Steel and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe.

N. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.

O. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2", and where pipe size is less than 1-1/2", and do not thread nipples full length (no close-nipples).

2.3 COPPER TUBE AND FITTINGS:

A. Copper Tube: ASTM B 88; Type K, L (wall thickness) as indicated for each service; hard-drawn temper, except as otherwise indicated. Do not use Type M piping.

B. DWV Copper Tube: ASTM B 306.

C. ACR Copper Tube: ASTM B 280.

D. Cast-Copper Solder-Joint Fittings: ANSI B16.18.

E. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.

F. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23.

G. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.

H. Cast-Copper Flared Tube Fittings: ANSI B16.26.

I. Bronze Pipe Flanges/Fittings: ANSI B16.24.

J. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.4 CAST-IRON SOIL PIPES AND PIPE FITTINGS:

A. Hubless Cast-Iron Soil Pipe: FS WW-P-401.

B. Cast-Iron Hub-and-Spigot Soil Pipe: ASTM A 74.

C. Hubless Cast-Iron Soil Pipe Fittings: Neoprene gasket complying with ASTM C 564 and stainless steel clamp holding band.

D. Cast-Iron Hub-and-Spigot Soil Pipe Fittings: Match soil pipe units; complying with same standards (ASTM A 74).

E. Compression Gaskets: ASTM C 564.

2.5 PLASTIC PIPE AND PIPE FITTINGS:

A. Polyvinyl Chloride Pipe (PVC): ASTM D 1785. Schedule 80. Plenum Rated.

B. PVC Fittings:

1. Schedule 80 Socket: ASTM D 2467.

2. Schedule 80 Threaded: ASTM D 2464.

2.6 GROOVED PIPING PRODUCTS: (Only where acceptable.)

A. General: At Installer's option, mechanical grooved pipe couplings and fittings may be used for piping systems having operating conditions not exceeding 230°F (110°C), excluding steam piping, condensing water return to pump, and any other service not recommended by manufacturer, in lieu of welded, flanged, or threaded methods, and may also be used as unions, seismic joints, flexible connections, expansion joints, expansion compensators, or vibration reducers.

B. Coupling Housings Description: Grooved mechanical type, which engages grooved or shouldered pipe ends, encasing an elastomeric gasket which bridges pipe ends to create seal. Cast in two or more parts, secure together during assembly with nuts and bolts. Permit degree of contraction and expansion as specified in manufacturer's latest published literature. (Victaulic style 77) For rigid joints (Victaulic "Zero Flex" style 07).

1. Coupling Housings: Malleable iron conforming to ASTM A 47.

2. Coupling Housings: Ductile iron conforming to ASTM A 536.

3. Standard: Enamel coated, options hot dip galvanized.

C. Gaskets: Mechanical grooved coupling design, pressure responsive so that internal pressure serves to increase seal's tightness, constructed of elastomers having properties as designated by ASTM D 2000.

1. Water Services: EPDM Grade E, with green color code identification.

2. Other Services: As recommended by Manufacturer.

D. Bolts and Nuts: Heat-treated carbon steel, ASTM A 183, minimum tensile 110,000 psi.

1. Exposed Locations: Tamper resistant nuts.

E. Branch Stub-Ins: Upper housing with full locating collar for rigid positioning engaging machine-cut hole in pipe, encasing elastomeric gasket conforming to pipe outside diameter around hole, and lower housing with positioning lugs, secured together during assembly with nuts and bolts.

F. Fittings: Grooved or shouldered end design to accept grooved mechanical couplings.

1. Malleable Iron: ASTM A 47.

2. Ductile Iron: ASTM A 536.

3. Fabricated Steel: ASTM A 53, Type F for 3/4" to 1-1/2"; Type E or S, Grade B for 2" to 20".

4. Steel: ASTM A 234.

G. Flanges: Conform to Class 125 cast iron and Class 150 steel bolt hole alignment.

1. Malleable Iron: ASTM A 47.

2. Ductile Iron: ASTM A 536.

H. Specialties:

1. Dielectric couplings. Victaulic Style 47.

I. Grooves: Conform to the following:

1. Standard Steel: Roll grooved.

2. Ductile Iron: Radius cut grooved, AWWA C606.

J. Manufacturer: Subject to compliance with requirements, provide grooved piping products of one of the following:

1. ITT Grinnell Corp.
2. Victaulic Co. of America.
3. Gustin-Bacon

K. Coordination with Section 23 07 00: Insulation of coupled piping is more difficult and expensive than is that of welded piping related to couplings, coupling ears, and more involved support. Where coupled piping is used, include all extra cost in the proposal. Install such at no additional cost to the owner.

2.7 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.

1. Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.

B. Soldering Materials: Except as otherwise indicated, provide soldering materials as determined by Installer to comply with installation requirements. Use no lead bearing solders in domestic water applications.

1. Tin-Antimony Solder: ASTM B 32, Grade 95TA.
2. Silver-Lead Solder: ASTM B 32, Grade 96TS.

C. Brazing Materials: Except as otherwise indicated, provide brazing materials as determined by Installer to comply with installation requirements.

1. Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.

D. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.

E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.

1. Manufacturer: Subject to compliance with requirements, provide piping connectors of the following:

a. Fernco, Inc.

F. Strainers:

1. Y pattern, self cleaning, line size. Armstrong, Bailey, Crane, Fisher, Metraflex, Mueller, Sarco, Strong, or Yarway.

a. Iron Body, Screwed Ends 2" and Smaller: 250 psig at 425^{o}F, screen mesh to suit service.

b. Flanged Iron Body 21/2" and Larger: 125 psig steam pressure rating, screen mesh to suit service.

2. Basket pattern, Mueller #155 to 30 psi, with quick release flanged lid Mueller #165 to 175 psi, with bolt on flanged lid.

PART III - EXECUTION

3.1 INSTALLATION:

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently- leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible union, flanges, etc., for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" misalignment tolerance. Do not cold spring. Store filler weld materials in accordance with codes.

1. Comply with ANSI B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, columns and other clearance to 1/2" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation. Wherever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated. Provide high point vents, low point drains with valves and extension to drain for all piping.

C. All piping in mechanical rooms, fan rooms, etc., shall be exposed. Do not conceal or imbed piping in walls, floors or other structures.

D. Make changes in direction or size with manufactured fittings. Anchor and support piping for free expansion and movement without damage to piping, equipment or to building.

E. Arrange piping to maintain head room and keep passageways clear.

F. Provide unions at connections to equipment and elsewhere as required to facilitate maintenance.

G. Run full pipe size through shutoff valves, gas cocks, balancing valves, etc. Change pipe size within three pipe size diameters of final connection to equipment, coils, etc.

H. Erect all piping to insure proper draining. Domestic water, chilled water, and heating water shall slope down a minimum of 1" per 40 feet towards the drains. Pitch standpipes down to fire department connections a minimum of 1" per 40 feet. Slope soil, waste, vent, and roof drain lines in accordance with requirements of Uniform Plumbing Code.

I. On horizontal straight runs of pipe, use eccentric reducers with straight side on top for water piping.

J. Electrical Equipment Spaces: Do not run piping in or through transformer vaults and other electrical or electronic equipment spaces and enclosures or above electrical gear unless authorized and directed. Install drip pan under piping that must be run through electrical spaces.

3.2 PIPING SYSTEM JOINTS:

A. General: Provide joints of type indicated in each piping system.

B. Threaded: Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. Brazed: Braze copper tube-and-fitting joints where indicated, in accordance with ASME B31.

D. Soldered: Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. Welded:

1. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31.

2. Weld pipe joints in accordance with recognized industry practice and as follows:

a. Weld pipe joints only when ambient temperature is above 0^{o}F (-18^{o}C) where possible, with minimum pipe preheat to 50^{o}F.

b. Bevel pipe ends at a 37.5^{o} angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.

c. Use pipe clamps or tack-weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".

d. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

e. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

f. At Installer's option, install forged branch-connection fittings wherever branch pipe is indicated; or install regular "T" fitting.

g. At Installer's option, install forged branch-connection fittings wherever branch pipe of size smaller than main pipe is indicated; or install regular "T" fitting.

F. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

G. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions.

H. Grooved Pipe Joints: Comply with fitting manufacturer's instructions for making grooves in pipe ends. Remove burrs and ream pipe ends. Assemble joints in accordance with manufacturer's instructions.

3.3 CLEANING, FLUSHING, INSPECTING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Flushing shall consist of not less than six (6) short intermittent flushes of five (5) to ten (10) minutes duration. Sample and test each flush for cleanliness. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Disinfect water mains and water service piping in accordance with AWWA C601.

C. Clean, flush as above and treat heating and cooling systems in accordance with Sections chemical treatment. Certify by signature of Contractor and Owner's Representative.

3.4 PIPING TESTS:

A. General: Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

1. Required test period is 2 hours.

2. Test long runs of Schedule 40 pipe at 150 psi, except where fittings are lower Class or pressure rating.

3. Test each piping system at 150% of operating pressure indicated, but not less than 25 psi test pressure.

4. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drop exceeds 5% of test pressure.

B. Notifications: At least 10 days prior to commencement of required testing, notice shall be submitted for review. Tests shall be made prior to painting insulating or covering of any

joints and shall be in accordance with ANSI Code for Pressure Piping.

C. Inspections: Contractor to visually inspect piping while under hydrostatic pressure. Copies of inspection shall be submitted for review. At option of contract, welds not hydrostatically tested may be x-ray tested.

D. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

E. Drain test water from piping systems after testing and repair work has been completed.

F. Test pressure piping in accordance with ANSI B31.

G. Test waste, drain and vent systems in accordance with local plumbing code and these specifications. Repair failed sections by disassembly and reinstallation.

H. If test procedures in other sections differ from the above, comply with more stringent requirements.

3.5 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 232113

SECTION 232113.23 - HYDRONIC PIPING AND SPECIALTIES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. All pertinent sections of Division 23 “General Mechanical Requirements” are a part of the work described in this section.

B. All pertinent sections of Division 23 “General Pipes and Fittings” are a part of the work described in this section.

C. Other Specification sections related to Insulation, System Commissioning, Testing and Balancing.

1.2 SUMMARY: Work shown on the drawings and required by these specifications including incidental work classified as "best practices of the trade".

A. Heating water systems.
B. Chilled water systems.
C. Other work as indicated.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of hydronic piping products and equipment of types, materials and sizes required, whose products have been in service for not less than 5 years.

B. Installer's Qualifications:

1. Firm with at least 3 years history of successful experience on projects of similar nature.

2. Licensed as a firm in the Contractor state of origin and in the State of Utah.

3. Have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

4. All workmen employed on the project shall carry state licenses as journeyman or apprentice pipe fitters with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical literature indicating source, brand, type, model, performance characteristics, installation instructions, etc.

B. Record Drawings: See Division 23.

C. Operation And Maintenance Information: Provide information for all equipment including a comprehensive system operating description. See Section 23 01 00.

D. Instruction Of Owner's Personnel: Participate in specified instruction. See Division 23.

1. As part of the overall project warranty, furnish individual manufacturer warranties for each piece of equipment for a period of not less than one year from date of Owner's beneficial use (substantial completion).

2. Warrant the overall assembly of equipment, materials and labor comprising these systems.

1.5 REFERENCES:

A. Standards: Comply with applicable sections, follow recommended practices.

1. State Boiler and Pressure Vessel Regulations

2. ASME Codes for Boilers and Pressure Vessels

3. State and Local Plumbing and Mechanical Codes

4. International Building Code/International Mechanical Code / International Plumbing Code

5. ASHRAE Handbooks

PART II - MATERIALS AND METHODS - HEATING WATER, CHILLED WATER,

2.1 PIPING AND FITTINGS:

A. Schedule 40 black steel, A-53 with malleable steel threaded fittings up to 2" size and forged steel welding fittings 2-1/2" and larger. Contractor option to use a grooved joint system accommodating for additional support and insulation work.

1. Rigid type “K” or “L” copper, bronze or dielectric interface.

B. Drains And Overflow: Install piping of any size from drains and overflows using type K or L copper piping with Solder joint type wrought copper of wrought bronze fittings. Drains and over flows shall be terminated over floor drains or drain funnels adjacent to equipment. Furnish drains from all pump bases to floor drains.

C. Water Connections: Provide piping and fittings connecting to the domestic water system, such as fill lines, makeup water lines, etc., of Type K or L copper tubing with solder joint type wrought copper or wrought bronze fittings. Copper piping shall be connected to equipment and steel piping with insulated unions to prevent electrolysis.

2.2 GENERAL SERVICE VALVES: Comply with Section "Valves".

A. General: Provide valves complying with Division 23 General Mechanical Materials and Methods section "Valves", in accordance with the following listing.

1. Sectional Valves:

a. 2" and Smaller: Ball valves.
b. 2 ½" and Larger: Butterfly valves.

2. Shutoff Valves:

a. 2" and Smaller: Ball valves.
b. 2 ½" and Larger: Butterfly valves.

3. Drain Valves:

a. 2" and Smaller: Ball valves.

4. Check Valves:

a. All Sizes: Swing check valves where space permits, else use wafer type.
b. Pump Discharge: Non-slam, pump discharge check.

2.3 MISCELLANEOUS VALVES AND SPECIALTIES: See Section "Valves".

2.4 CIRCUIT BALANCE VALVES:

A. Circuit balance valve for flow balance complying with Section “Valves”.

2.5 VENT VALVES:

A. Manual Vent Valves: Provide manual vent valves designed to be operated manually. Use ball valve.

B. Automatic Vent Valves: Provide automatic vent valves designed to vent automatically with float principle, stainless steel float and mechanisms, cast-iron body, pressure rated for 125 psi, 1/2" NPS inlet and outlet connections.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering vent valves which may be incorporated in the work include, but are not limited to, the following:

1. Armstrong Machine Works.
2. Bell & Gossett ITT; Fluid Handling Div.
3. Hoffman Specialty ITT; Fluid Handling Div.
4. Spirax Sarco.
5. Amtrol.

2.6 WATER RELIEF VALVES:

A. Heating Water or Chilled Water System Relief:

1. Iron or bronze body, ASME, pressure setting as required.

2. Acceptable Manufacturers: Subject to compliance with requirements, provide relief valves of one of the following:

a. Bell and Gossett 3301 or 790
b. Watts.
c. Taco

2.7 PRESSURE REDUCING VALVES:

A. Heating water service and/or chilled water service, brass body, removable strainer, adjustable setting, 125 psi maximum pressure rating. Select proper size for maximum flow rate and required inlet and outlet pressures.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide pressure reducing valves of one of the following:

1. Bell and Gossett "7"
2. Watts.

2.8 STRAINERS:

A. General: Y pattern, self cleaning, line size.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide strainers of one of the following:

1. Armstrong
2. Watts
3. Victaulic
4. Mueller
5. Spirex Sarco
6. Metraflex

C. 2" and Smaller: Watts No. 77S or equal in Armstrong, 250 lb. iron body, threaded, Y-pattern, 20-mesh stainless steel screen, full size drain connection with ball valve.

D. 2-1/2" and Larger: Watts No. 77F-125 or equal in Armstrong, 125 lb. iron body, flanged, Y-pattern, stainless steel screen, drain connection with ball valve.

E. Basket Type: (for condenser/tower water) 175 psig WWP, iron body, flanged ends, stainless steel basket with 1/8” perforations with bolted/ gasketed cover. Bottom tapped drain connection. Selection based on Mueller number 165, Metraflex.

2.9 BALANCING COCKS:

A. 2" and Smaller: 175 psig WOG, cat iron body, square head, screwed ends, wrench operated, lubricated.

B. 2-1/2" and Larger: 200 psig WOG, cast iron body, square head, flanged ends, wrench operated, lubricated.

2.10 EXPANSION TANKS:

A. General: Provide expansion tanks of type, size, and capacity as scheduled and as specified herein.

B. Extent of Work: Furnish and install expansion tanks as sheduled. Charge tank to local static pressure. Tanks shall be ASME certified and stamped for 125 psig working pressure.

1. Expansion Tanks: Factory built unit, pressurized diaphragm type, ASME certified and stamped for 125 psig working pressure. Tank shall contain a flexible neoprene diaphragm to separate the air charge from the water system. Furnish with air charging valve and threaded water connection. Charge tanks to local static water pressure.

C. Manufacturer: Subject to compliance with requirements, provide expansion tanks and air separator of one of the following:

1. American Tube and Controls “Extrol”

2. Bell and Gossett
3. Armstrong

D. Installation: Each expansion tank shall sit on a new concrete pad and be secured to the structure or mounted horizontally from the structure. Provide piping and valving as shown on drawings. Seismically anchor to structure.

2.11 AIR SEPARATOR:

A. Furnish and install, as shown on plans, an in-line type air separator. A centrifugal unit shall have inlet and outlet connections tangential to the vessel shell. Vessel shell diameter to be three times the nominal inlet/outlet pipe diameter.

B. The unit shall have an internal stainless steel air collector tube with 5/32" (4mm) diameter perforations and 63% open area designed to direct accumulated air to the compression tank via an NPT vent connection at top of unit.

C. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

D. The air separator must be designed, constructed and stamped for 125 psig @ 350ºF in accordance with Section VIII, Division I and the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The air separator(s) shall be painted with one shop coat of light gray air dry enamel.

E. Manufacturer: Subject to compliance with requirements provide air separators of one of the following:

1. Amtrol
2. Bell & Gossett
3. Armstrong
4. Taco

2.12 FLEXIBLE CONNECTIONS:

A. Extent of Work: At the inlet and outlet of each pump, and at piping connections to motorized equipment, furnish and install flexible connections comprised of not less than three grooved joint couplings with EPDM gaskets in close proximity. In assembly, position joints to accept anticipated expansion and movement. Install adjacent piping without force or strain.

PART III - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which hydronic piping systems materials and products are to be installed.

3.2 GENERAL SYSTEM INSTALLATION:

A. Arrange system in a neat, orderly and functional manner. Maintain access around all equipment. Provide sheeves for all structural penetrations.

B. Plan ahead for seismic restraint and vibration isolation.

C. Verify adequate ventilation for heat producing equipment, watch out for possible freezing conditions.

D. Air Vents and Line Drains: Provide air vents at all high points of piping systems with vent line extended to valve installed in accessible location 5'-0" above the floor, vent line extended to drain. Provide drain valves at all equipment and at low points in the system, extend drain lines to drain funnel or floor sink.

E. Provide pressure gauges and thermometers and pressure/temperature plugs as indicated on the flow diagrams, piping plans and equipment details.

3.3 INSTALLATION OF HYDRONIC PIPING:

A. General: Install hydronic piping in accordance with Division 23 “General Pipes and Fittings."

B. Install eccentric reducers where pipe is reduced in size in direction of flow, with tops of both pipes and reducer flush.

C. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

3.4 INSTALLATION OF PIPING SPECIALTIES:

A. Install piping specialties in accordance with Division 23 "Hydronic Piping and Specialties."

3.5 INSTALLATION OF SUPPORTS AND ANCHORS:

A. Install supports and anchors in accordance with Division 23 "Mechanical Supporting Devices."

3.6 INSTALLATION OF VALVES:

A. Install valves in accordance with Division 23 "Valves."

B. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves 2 or more hydronic terminals or equipment connections, and elsewhere as indicated.

C. Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, and on inlet of each hydronic terminal, and elsewhere as indicated.

D. Hydronic Terminal Outlet Valves: Install on inlet of each hydronic terminal, and elsewhere as indicated.

E. Drain Valves: Install on each mechanical equipment item located to completely drain equipment for service or repair. Install at base of each riser, at base of each rise or drop in piping system, and elsewhere where indicated or required to completely drain hydronic piping system.

F. Check Valves: Install on discharge side of each pump, and elsewhere as indicated.

3.7 INSTALLATION OF EXPANSION COMPENSATION PRODUCTS:

A. General: Provide for expansion and contraction of all piping systems with anchors, guides, loops, expansion joints, grooved joints, etc. Provide one expansion loop for every 100 feet

of pipe or fraction thereof.

3.8 EQUIPMENT CONNECTIONS:

A. General: Connect hydronic piping systems to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated. Install shutoff valve and union on supply and return, drain valve on drain connection.

B. Hydronic Terminals: Install hydronic terminals with hydronic terminal shut-off valve and union on outlet; union, shutoff valve on inlet. Install manual air vent valve on element in accordance with manufacturer's instructions. Locate valves and balancing valves behind valve access doors for ease of maintenance. Where indicated, install automatic temperature control valve with unions on supply line.

3.9 INSTALLATION OF HYDRONIC SPECIALTIES:

A. Balance Valves: At locations shown on drawings.

B. Vent Valves:

1. Manual Vent Valves: Install manual vent valves on each hydronic terminal at highest point, and on each hydronic piping drop in direction of flow for mains, branches, and runouts, and elsewhere as indicated.

2. Automatic Vent Valves: Install automatic vent valves at top of each hydronic riser and elsewhere as indicated. Install shutoff valve between riser and vent valve, pipe outlet to suitable plumbing drain, or as indicated.

C. Air Separators:

1. In-line Air Separators: Install in-line air separators in pump suction lines as shown on drawings. Connect inlet and outlet piping. Run piping to compression tank with 1/4" per foot (2%) upward slope towards tank.

D. Diaphragm-Type Expansion Tanks: Install diaphragm-type expansion tanks on pad or from structure as indicated, in accordance with manufacturer's instructions. Seismically anchor tank. Provide piping and valving as shown on the drawings. Vent and purge air from hydronic system, charge tank with proper air charge.

E. Water Relief Valves: Install on heating water system as indicated.

F. Pressure Reducing Valves: Install for makeup water to heating water system. Provide pressure gauge down stream of reducing valve. Provide union connection at reducing valve.

3.10 TESTS:

A. Isolate sections of piping and equipment and pressure test to 175 psi or 1-1/2 times the maximum potential pressure of the system, but not to exceed the test pressure rating of a system component.

1. Conduct an air pressure test, using a soap solution to check for leaks. Establish the pressure, close off the pressure source and let stand for 24 hours. Given constant temperature, there should be no drop in pressure.

2. After the air test, fill the system with water, raise to test pressure and inspect for

leaks. Repair all leaks. Repeat tests. Report and certify all tests.

B. Test other system components as needed to verify proper assembly and installation.

C. Participate in overall system test and balance work.

3.11 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 232113.23

SECTION 232500 - CHEMICAL WATER TREATMENT FILTERS AND EQUIPMENT

PART I - GENERAL

1.1 DESCRIPTION OF WORK:

A. Types of chemical treatment specified in this section include the following:

1. Shot Feeders.
2. Heating Water Bypass Filter.
3. Chilled Water System.
4. Cleaning and Treatment.
5. Domestic Water System Disinfection.

PART II - PRODUCTS

2.1 SHOT FEEDERS:

A. General: Provide shot feeders of 5 gal. capacity or otherwise as indicated, constructed of cast-iron or steel, for introducing chemicals in hydronic system. Provide with 3/4" valved connections, valved vent, valved drain and removable screw cap for filling valved connections. Construct for pressure rating of 150 psi.

B. Manufacturer: Subject to compliance with requirements, provide shot feeders of one of the following:

1. Calgon
2. Jimbo
3. Wingert
4. Neptune

2.2 GLYCOL MAKE-UP UNIT: Provide glycol and glycol make-up unit for heating water system complete with the following:

A. 30% glycol by volume for entire chilled water system. Inhibited propylene glycol as manufactured by Dow Chemical Dowfrost HD or Union Carbide.

B. Polyethylene feed tank mounted on a steel frame with accommodations for mounting a pump underneath. Tank shall have a hinged lid and all interconnecting piping to pump including strainer.

C. Level switch to deactivate pump and activate alarm on low level.

D. Control panel to house switching device for pump, audible alarm, HOA switch for pump, lights to indicate power and low level, pushbutton for alarm silence. Enclosure shall be NEMA 12. Control panel shall be mounted on the tank stand.

E. Rotary gear pump of bronze construction. Capacity shall be as scheduled on the drawings.

F. ½" bronze, solenoid valve mounted in the feed line from the pump to the system. The valve shall be activated the same time as the pump.

G. Pressure switch set at such a psig (adjustable) to activate the pump and solenoid valve. Pump shall be deactivated at adjustable psig. Pressure sensing shall be made in the main chilled water line on the discharge side of the pump.

H. ½" bronze, relief valve mounted on the system side of the solenoid valve and piped back to the tank.

I. Manufacturers: Glycol make-up unit shall be manufactured by the following manufacturers:

1. Power Engineering Company
2. Aurora
3. Pacific
4. Neptune

PART III - EXECUTION

3.1 HEATING WATER AND CHILLED WATER SYSTEM CLEANING AND TREATMENT:

A. Provide valved bypass lines as needed to allow recirculation. Provide valve connections needed to fill, vent and drain system.

1. Use a treatment schedule similar to the following, but to be verified compatible with system materials. Provide report defining work done and periodic requirements to maintain system. Provide any recommendations relevant to insuring along term operable system.

2. Fill, circulate, drain system, clean strainers. Use clean water.

3. Fill, introduce 3 lbs per 1,000 gallon of crystalline trisodium phosphate plus 0.025% wetting agent (TIDE) or other suitable degreaser, take the water to operating temperature, circulate for minimum of 5 hours, drain, flush.

4. Fill, clean and flush and sterilize where appropriate, all water piping systems with water and drain these systems before they are placed in operation. Flushing shall consist of not less than six (6) short, intermittent flushes of five (5) to ten (10) minutes duration. Sample and test each flush for cleanliness. Blow out all other piping systems with compressed air or nitrogen to remove foreign materials that may have been left or deposited in the piping system during its erection.

5. Fill heating and chilled water system with water, ready for final treatment.

6. For building heating and chilled water system; fill, introduce oxygen inhibitor such as sodium borate-nitrite with phenopthalien, circulate.

7. For building heating and chilled water system; maintain inhibitor for entire first year, replace if lost.

8. For building heating and chilled water system; for one year, water treatment company to supply chemicals,and appropriate on-site service.

3.2 DOMESTIC WATER SYSTEM: Refer to Division 22 “Water Distribution Piping and Equipment” for cleaning and disinfection.

3.3 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 232500

SECTION 233100 - DUCTWORK

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Basic Mechanical Materials and Methods Sections apply to work of this section.

1.2 SUMMARY:

A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

B. Types of ductwork required for the project include the following:

1. Round
2. Rectangular
3. Oval
4. Spiral
5. Factory

C. Exterior Insulation of metal ductwork is specified in other Division 23 sections, and is included as work of this section.

D. Refer to other Division 23 sections for exterior insulation of metal ductwork; not work of this section.

E. Refer to other Division 23 sections for ductwork accessories; not work of this section.

F. Refer to other Division 23 sections for fans and air handling units; not work of this section.

G. Refer to other Division 23 sections for mechanical controls; not work of this section.

H. Refer to other Division 23 sections for louvers; not work of this section.

I. Refer to other Division 23 sections for filters; not work of this section.

J. Refer to other Division 23 sections for motorized dampers.

K. Refer to other Division 23 sections for air control boxes; not work of this section.

L. Refer to other Division 23 sections for grilles and diffusers; not work of this section.

M. Refer to other Division 23 sections for system commissioning, testing and balancing; not work of this section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects with metal ductwork systems work similar to that required for project.

1. The installer shall have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

2. All workmen on the project shall carry state licenses as journeymen or apprentice sheet metal workers with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for metal ductwork materials and products.

B. Shop Drawings: Submit scaled layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spacial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

C. Record Drawings: At project closeout, submit record drawings of installed metal ductwork and ductwork products, in accordance with requirements of General Conditions.

D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes and Standards:

1. SMACNA Standards: Comply with SMACNA "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork and “HVAC Duct Leakage Test Manual”.

2. AMCA Compliance: Test and rate plenums in accordance with AMCA Standards.

3. ASHRAE Standards: Comply with ASHRAE Handbook, Equipment Volume, Chapter 1 "Duct Construction", for fabrication and installation of metal ductwork.

4. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air-Conditioning and Ventilating Systems" and NFPA 90B "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems".

5. International Building Code/International Mechanical Code: Comply with all sections pertaining to mechanical work.

B. Field Reference Manual: Have available for reference at project field office, copy of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Protection: Protect shop-fabricated and factory-fabricated ductwork, plenums, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts, fittings and plenums.

B. Storage: Where possible, store ductwork and plenums inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

PART II - PRODUCTS

2.1 DUCTWORK - GENERAL:

A. Standards: All duct fabrications shall comply with standards and techniques detailed by SMACNA "Duct Construction Manuals" for the appropriate pressure class, and with the ASHRAE Handbook, 1988 edition, Chapter 1, Duct Construction

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality, with G 90 zinc coating in accordance with ASTM A 525; mill phosphatized for exposed locations.

C. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting. Installation of exposed ductwork shall be laid out in advance and submitted for review. Ductwork shall be hung straight and uniform, points shall be true, seams shall show continuity.

D. Stainless Steel Assemblies: Fabricate of Type 304 SS or Type 316 SS stainless steel sheet complying with ASTM A-167 with all welded joints and seams. Provide polished No. 4 satin finish for all hoods and duct exposed to view, No. 1 finish elsewhere. Protect finished surfaces with mill applied adhesive protective paper through fabrication and installation.

2.2 FITTINGS AND FABRICATION:

A. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15^{o} change of direction per section. Unless specifically detailed otherwise, use 45^{o} lateral and 45^{o} elbows for branch take-off connections. Where 90^{o} branches are indicated, provide conical type tees.

B. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30^{o} for contracting tapers and 20^{o} for expanding tapers.

C. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division 23 section "Duct Accessories' for accessory requirements.

D. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners.

E. Offset, transition, adapt ductwork to structural obstacles and work of other trades in a coordinated effort. Layout work to avoid conflict with piping, etc. With review of conditions, teardrop around conflicting piping, lights, etc., all at no added cost to the owner.

2.3 DUCT PRESSURE CLASSIFICATIONS:

A. For all VAV systems, which include but are not limited to

1. From fan discharge to air terminal unit: medium pressure ductwork, 10" w.g.

2. Rectangular supply air ductwork from air terminal unit, rectangular and round ductwork: Low pressure rectangular ductwork, 3" w.g. Low pressure round ductwork exposed to view spiral backseam, 3" w.g.

3. Branch round supply air ductwork runout from rectangular ductwork to diffuser: Low pressure round ductwork, 1" w.g.

4. Outside air ductwork and plenums, 10" w.g.

5. Relief air plenums, 3" w.g.

B. Low pressure exhaust ductwork and ventilation systems, which include but are not necessarily limited to exhaust fan systems and ventilation systems.

1. Low pressure rectangular ductwork, 3" w.g. Increase metal gauge by 2 (i.e., 20 to 18) for all sizes.

2.4 LOW PRESSURE ROUND DUCTWORK: (1" SMACNA Pressure Class)

A. Round type ductwork for use on low velocity supply systems (1200 fpm maximum), low pressure (0.75" maximum duct pressure), shall be fabricated on 26 gauge galvanized steel sheets with snap-lock longitudinal seams and crimped and beaded joins.

B. All end joints shall have at least three screw fasteners and shall be wrapped airtight. Transverse and longitudinal seams shall be taped with "Hardcast TA". Elbows and fittings shall provide smooth air flow patterns and have a neat appearance.

C. Use factory fabricated elbows of the multi-sectional adjustable type.

2.5 LOW PRESSURE RECTANGULAR DUCTWORK: (3" SMACNA Pressure Class)

A. Rectangular ductwork for use on supply systems up to 2" maximum duct static pressure and 2000 fpm maximum duct velocity shall be constructed of galvanized steel using construction for nominal 3" SMACNA rated systems. Seal all transverse joints with duct cement or tape with "Hardcast TA".

B. Use radius elbows or turning vanes with extended trailing edge. Use a true 1-1/2 time 45^{o} tapping takeoffs with downstream balance damper.

C. Duct dimensions are inside clear. Increase for acoustical lining.

D. For rectangular exhaust ducts, increase metal gauge by 2 (i.e. 20 to 18) for all sizes. Seal all joints.

2.6 MEDIUM PRESSURE DUCTWORK: (10" SMACNA Pressure Class)

A. General: At Installer's option, provide factory-fabricated duct and fittings, in lieu of shop-fabricated duct and fittings.

B. Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.

Diameter	Minimum Gauge	Method of Manufacture
3" to 14"	26	Spiral Lockseam
15" to 26"	24	Spiral Lockseam
27" to 36"	22	Spiral Lockseam
37" to 50"	20	Spiral Lockseam
51" to 60"	18	Spiral Lockseam
Over 60"	16	Longitudinal Seam
60" to 84"	18	Spiral Lockseam

Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct.

C. Round Duct Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams. Mitered elbows shall be of at least 5 piece construction with R/D ratio of 1.5. All branch takeoffs shall be a true 45º takeoff having an overall throat width at the main duct connection of 1-1/2 times the sizes of the branch duct.

Diameter	Minimum Gauge
3" to 36"	20
38" to 50"	18
Over 50"	16

D. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam or longitudinal seam construction, in minimum gauges listed.

Maximum Width	Minimum Gauge Spiral	Longitudinal
Under 25"	24	22
25" to 48"	22	20
49" to 70"	20	18 Stiffener Inserts 4'-0" on Center

E. Flat-Oval Duct Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

Maximum Width	Minimum Gauge
Under 37"	20
37" to 50"	18
Over 50"	16

F. Internally Insulated Duct and Fittings: Construct with outer pressure shell, 1" or 2" thick (as indicated on drawings) insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed. Use where indicated on drawings.

Equivalent to United McGill "Acoustic-K27".

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 12"	26 gauge	24 gauge
13" to 24"	24 gauge	24 gauge
25" to 34"	22 gauge	24 gauge
35" to 48"	20 gauge	24 gauge
49" to 58"	18 gauge	24 gauge
Over 59"	16 gauge	20 gauge

G. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell. Construct fittings to close tolerance with ductwork.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 34"	20 gauge	20 gauge
36" to 48"	18 gauge	20 gauge
Over 48"	16 gauge	20 gauge

H. Field joints shall be made up using an initial coat of 3M EC-750 adhesive wrapping the joint with a 3" wide fiberglass strip and applying a final seal coat of adhesive to the fiberglass. Duct sections and fittings shall be held in place at joints with sheet metal screws 6" on centers. Simple coating of joint surfaces with mastic prior to joining is not acceptable (SMACNA Std. P.1-11).

As an alternative method of duct joint sealing, the joints shall be held in place with screws as specified, but the contractor may use "Thermofit" duct sealing bands as manufactured by Rayclad Tubes of Menlo Park, California. Bands shall be installed according to the manufacturer's directions. The open flame shall not be used in the vicinity of combustible materials.

I. Oval ductwork shall be installed where called for on the plans and where required to conform to tight space requirements encountered during construction. The contractor shall furnish transition pieces as required. Oval ductwork shall have equivalent capacity to the round duct.

At the Contractor's option odd inch diameter round ducts may be increased in size to the next larger even inch providing space considerations are accommodated and all related conditions are resolved by the contractor.

2.7 FACTORY DUCT:

A. Extent of Work: Provide factory duct at connections to air terminal units, at runouts to grilles and diffusers, at points of round to round flexible connections (see also "Flexible Connections") and at other locations indicated or required.

B. Prohibited Material: Do not use single wire helix ducting with vinyl or plastic liner of any type.

C. Factory Duct Non-corrosive Environments: Woven fiberglass fabric impregnated with vinyl or neoprene clamped in a continual helix of aluminum or cold rolled steel. U.L. listed for

Class 1 duct, compliant with NFPA 90A and 90B, pressure rated to 12" w.g., equivalent to:

D. Non-insulated: Wiremold 57; Flexmaster Type N145

E. Insulated: Flexmaster Type 4; Thermaflex M-KC

F. Installation: Follow manufacturers instructions. Use stainless steel or nylon band clamping rings. In general, do not use lengths in excess of 3 feet. Make bends only in long radius format. Support duct to avoid droops and kinks.

2.8 DRYER EXHAUST DUCTWORK

A. General: All dryer exhaust ductwork and fittings shall be constructed and fabricated from aluminum.

B. Aluminum Ductwork and Fittings:

1. Round Ductwork: Construct of 3003-H14 aluminum by the following methods and in minimum thickness listed.

Diameter	Minimum Thickness	Method of Manufacturer
3” to 4”	0.019”	Snap lock or modified hat lock

2. Round Fittings and Couplings: Construct of minimum thickness listed from 3003-H14 aluminum, smooth radius elbows shall be used with a minimum RD ratio of 1.5.

3. Field joints for round ductwork and fittings shall be made up using crimped joints, inserted in the direction of airflow, and sealed with aluminum foil tape. Sheet metal screws, or other means of attachment that protrude into the duct, shall not be used.

2.8 MISCELLANEOUS DUCTWORK MATERIALS:

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Runout Fittings: Runout fittings shall be used to make round to rectangular duct connections. Use 45^{o} time and a half square to round fittings. Provide with locking quadrant dampers where balance is involved. Provide with insulation guard where insulated duct is involved.

C. Duct Sealing Compound: Duct sealing compound shall be 3M brand number EC-750 or Duro-Dyne S-2. This material shall be used in making up duct joints or in water proofing, caulking plenums, etc.

D. Acoustical Lining: Acoustical lining in ducts shall be 1" thick, 1-1/2 pound density, coated, flexible glass fiber type, set in adhesive and impaled on weld studs spaced not more than 12" on centers and secured with lock washers. Airstream surface faced with black coated matte. Acoustical lining shall completely line the ducts. Lining shall have a fire and smoke hazard rating not exceeding 20-50-50. Owens-Corning, Johns-Manville, Certainteed.

E. All joints, edges and/or surface breaks in the coating of the acoustical lining shall be finished to a smooth surface with adhesive.

F. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives and Duct Thermal Insulation".

G. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

H. Duct Cement: Non-hardening migrating mastic or liquid neoprene based cement (type applicable for fabrication/ installation detail) as compounded and recommended by manufacturer specifically for cementing fitting components, or longitudinal seams in ductwork.

I. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

2.9 AUXILIARY DRAIN PANS:

A. Extent of Work: Where a equipment cooling coil or duct mounted coil providing a cooling function is mounted in a ceiling plenum or other furred space, or under the emergency generator ventilation duct, provide a secondary drain. This may be an overflow drain connection or a corrosion resistant, water-tight drain pan either with drain line extended to a point of visible discharge. (Reference UMC Section 310, 1994 ed.)

B. Construct drain pan of 304 stainless steel with overlapped and soldered corners, with 1" Type M copper tube drain line. Provide long radius bends with cleanout plugs at each change in direction. Provide cleanouts every 20 feet or less with “wye” pattern fittings

2.10 BOILER FLUE:

A. Extent of Work: Provide a complete flue system for the new boilers.

B. Flues:

1. Double wall, prefabricated sectional category II of stainless steel inner liner construction designed to handle combustion products of fuel being used. Provide with inspection cap, roof flashing, and clean-out.

2. Size flues according to local codes and as indicated on the drawings except -

a. In no case shall vent connector be smaller than outlet collar provided by Manufacturer.

b. Horizontal flue connectors shall be double wall.

c. Fittings shall be pre-fabricated double wall.

3. Vent Caps. Non-backdraft type for installation on top of flue.

Approved Manufacturers -.

a. Ameri-Vent
b. Dura-Vent
c. Metalbestos
d. Metal-Fab Inc.
e. Ampco

PART III - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which metal ductwork and plenum are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF METAL DUCTWORK:

A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air tight (5% leakage for systems rated 3" and under; 1% for systems rated over 3") and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.

All necessary allowance and provisions shall be made in the installation of sheet metal ducts for the structural conditions of the building, and ducts shall be transformed or divided as may be required. Whenever this is necessary, the required area shall be maintained. All of these changes, however, must be approved and installed as directed at project. During the installation, the open ends of ducts shall be protected to prevent debris and dirt from entering.

B. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

C. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

D. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures. Maintain clearances above of and in front of electrical panels.

E. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2". Fasten to duct and substrate.

1. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate, in accordance with requirements of Section "Firestopping".

F. Ducts At Structural and Architectural Penetrations: Where ducts are shown connecting to or passing through concrete, gypsum board, masonry openings and along edges of all plenums at floors and walls, provide a continuous 2" x 2-1/8" galvanized angle iron which shall be bolted to the construction and made airtight to the same by applying caulking compound. Sheet metal in these locations shall be bolted to the angle iron. Round high velocity ducts in vertical chases shall be supported with rolled angle rings. Close openings between duct and structure.

G. Cross Breaking: Rectangular sheet metal ducts shall be cross broken on the four sides of each 4-foot panel. All vertical and horizontal sheet metal barriers, duct offsets, elbows, as well as 4-foot panels of straight sections of ducts shall be cross broken. Cross breaking shall be applied to the sheet metal between the standing seams or reinforcing angles; the center of cross break shall be of the required height to assure surfaces being rigid.

H. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

I. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards.

1. Related to final installation cleanliness, damp wipe all ductwork on installation. Cap open duct ends, cover fan inlets, vacuum fan plenums and related installation before starting fans. Run fans only with filters in place.

3.3 INSTALLATION OF DUCT LINER:

A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards.

As indicated on the drawings, supply, return and exhaust air ductwork shall be lined with acoustical insulation.

In all cases outside air ductwork shall be lined with 2' thick 1-1/2 lb. density acoustical lining unless indicated differently on drawings, ie. requiring Type 2 plenum.

3.4 INSTALLATION OF FLEXIBLE DUCTS:

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 3'-0" extended length. No elbows allowed.

B. Installation: Install in accordance with Section III of SMACNA's "HVAC Duct Construction Standards, Metal and Flexible".

3.5 HANGERS AND SUPPORTS:

A. It is essential that all ducts shall be rigidly supported. Hangers for low velocity ducts up to 18" in width shall be placed on not more than 10' centers.

Low velocity ducts 19" through 35" in width and greater shall be supported on not more than 5' centers. Where vertical ducts pass through floors or roofs, heavy supporting angles shall be attached to ducts, and to structure. Angles shall be of sufficient size to support the ductwork rigidly and shall be placed on at least two sides of the duct.

B. Construct hangers for rectangular ductwork from galvanized iron l" x 1/16". Hangers shall extend down the sides of rectangular ducts the full depth of the duct and shall be bent underneath the duct 2". Hangers shall be secured to the duct using sheet metal screws or rivets of appropriate sizes on 6" centers, but not less than two screws in the side and one in the bottom of each hanger.

C. For rectangular ducts 36" and greater in width construct hangers from galvanized iron 1-1/2" x 1/16". Hangers shall be installed and secured to duct as described in Paragraph B.

3.6 SUPPORTING DAMPERS: Parallel and opposed blade motor operated dampers shall be supported by reinforcing the ductwork or sheet metal walls at the damper locations to carry the weight of the dampers and the force exerted on the dampers due to air pressure, or shall be supported independent of ductwork from the ceiling or floor, as conditions at the site determine.

3.7 CONNECTIONS: Connections of high velocity supply and exhaust ducts, fittings, and high velocity mixing boxes shall be made airtight by coating joints with Minnesota Mining Co. Mastic, Type EC-800, Benjamin Foster, Sheet Metal Products Co., or approved equal, before joining, and then sealing the joint with one layer of "Glass-Fab" reinforcing tape set in a coating of the above compound. Tape and sealant shall not exceed a flame spread of 25 or a smoke development of 50.

3.8 WELDED JOINTS: Welded ductwork shall have either an angle or a piece of 1/8" steel bar behind each weld to allow laying of a neat and continuous bead.

3.9 AESTHETIC LAYOUTS: Contractor shall locate all diffusers, grilles and other exposed items in such a manner as to fit symmetrically in any grid system or other aesthetic architectural or lighting pattern. Refer to reflected ceiling plans and electrical lighting layouts for additional information. Provide duct offsets or extensions as required to make a proper installation.

Close or cap all duct ends. Use auxiliary blower with air flow meter to establish a duct pressure equivalent to the duct pressure class. Inspect all joints in duct system and seal all identifiable leaks.

3.10 FIELD QUALITY CONTROL:

A. Leakage Tests: After each duct system which is constructed for duct classes over 3" is completed, test for duct leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Air leaks which are in excess of that required to bubble the soap suds (that is, actually blow the suds away) shall be sealed by additional taping and caulking to reduce the leakage to a rate not to exceed slow bubbles forming. Repair leaks and repeat tests until total leakage conforms with Chart of Figure 4-1, Seal Class A, Leakage Class 3 for round/oval, 6 for rectangular.

3.11 EQUIPMENT CONNECTION:

A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.12 ADJUSTING AND CLEANING:

A. Clean ductwork internally of dust and debris, as follows: Before the ceilings are installed, with filters in place, operate the fans at full capacity to blow out dirt and debris from ducts.

If it is not practical to use the main supply blower for this test, the ducts may be blown out in sections by a portable fan.

B. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

C. Balancing:

1. Refer to Division 23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. However, the Sheet Metal Contractor shall participate fully in this work. Seal any leaks in ductwork that become apparent in balancing process.

2. If specified conditions cannot be obtained due to deficiencies in equipment performance or improper installation or workmanship, the Mechanical Contractor and his subcontractors shall make any changes necessary to obtain the specified conditions.

3.13 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 233100

SECTION 233300 - DUCTWORK ACCESSORIES

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 SUMMARY:

A. Extent of ductwork accessories work is indicated on drawings and in schedules, and by requirements of this section.

B. Types of ductwork accessories required for project include the following:

1. Dampers.
    a. Low pressure manual dampers.
    b. Control dampers.
2. Fire Smoke dampers.
3. Turning vanes.
4. Duct hardware.
5. Duct access doors.
6. Flexible connections.
7. Sound Traps

C. Refer to other Division 23 sections for testing, adjusting, and balancing of ductwork accessories; not work of this section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

C. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes and Standards:

1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".

2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.

3. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers".

4. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Protection: Protect shop-fabricated and factory-fabricated accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

B. Storage: Where possible, store accessories inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

PART II - PRODUCTS

2.1 DAMPERS:

A. Control dampers are furnished by this Section and installed by this Section. Dampers shall be supported, plenum openings shall be reinforced, the entire assembly shall be sturdy and operate smoothly. Install dampers to direct outside and return air into each other for mixing. Control dampers for relief air, return air, ventilation air, exhaust air, outside air, and supply air. Low leakage type with spring loaded side seals, inflatable butyl or neoprene fabric edge seals, bronze or teflon bearings, reinforced extruded aluminum airfoil blades, aluminum frame. Action as indicated on drawings. Air leakage not to exceed 5 CFM per square foot at 4" upstream static pressure.

1. Ruskin CD-50
2. Greenheck VCD-43

B. Control dampers for balance only where tight shutoff is not critical are to be furnished and installed by this Section. 6" galvanized blade, poly foam blade seals, flexible metal jamb. Parallel blade operation.

1. Ruskin CD-35
2. Greenheck

2.2 COMBINATION FIRE/SMOKE DAMPERS:

A. Galvanized hat-shaped steel channel frame, steel airfoil shaped double skin construction blades, silicone rubber blade edge seals, flexible compression jamb seals. Stainless steel bearings, fusible link UL 555S, leakage Class I. Furnish with factory installed damper operator to match the smoke control system. Damper and operator are to be qualified for 350°F category. Ruskin FSD 60 Class I or Greenheck or NCA. Damper and operator to be normally closed. Label (UL) all dampers. Use Honeywell electric non-exercising type actuator, links shall be 165°F for cold and return air, 212°F for hot air. Furnish with momentary push to test switch for each damper, factory wired.

2.3 TURNING VANES: Turning vanes shall be installed in all square elbows. Turning vanes shall be single blade. Turning vane spacing shall be per SMACNA. Each blade shall be tack welded or crimped to the carrier frame to prevent rattling.

2.4 DUCT HARDWARE:

A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:

1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, cover, for instrument tests. Ventlok No. 699 closures shall be provided and installed for each test hole, with sufficient neck length to penetrate the insulation.

2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork. (Bare duct - Ventlok 620, 635; Insulated duct - Ventlok 627, 628, 637, 638, 629.)

B. Manufacturer: Subject to compliance with requirements, provide duct hardware of one of the following:

1. Ventfabrics, Inc.
2. Young Regulator Co.

2.5 DUCT ACCESS DOORS: Doors shall be 2" narrower than the duct width by 24" up to a maximum of 24" x 24". Duct access doors shall be furnished for all fire damper links, manual controllers and adjustable balancing devices. Duct access doors for all ductwork (except low pressure ductwork) shall be: Bolted access door, oval shaped constructed of an outer door connected to a an inner plate by spring loaded carriage bolts with wing handles. Inner plate to have cellular spounge gasket for leak free operation up to 20"wg. The door shall have permanently bonded polyester insulation.

2.6 WALL AND CEILING ACCESS DOORS: Wall and ceiling doors at fire dampers and smoke dampers shall be the same as specified in Section 23 00 00. Doors shall be sized for easy access to fire links and not less than 24" x 24" where possible.

2.7 FLEXIBLE CONNECTIONS:

A. Extent of Work: Provide flexible connections between ductwork or plenums and equipment, such as at fan inlets and discharges, and at other places indicated on the drawings or called for by note or specification.

B. Non-Corrosive Environment or Airstream: Provide material of heavy waterproof woven glass fabric double coated with neoprene or hypalon equivalent to “Ventglas” for interior locations and “Ventlon” for exterior locations, fabric not less than 3-1/4" wide clamped between strips of 24 gauge galvanized iron. Material by Ventfabrics, Inc., Chicago, Ill.

2.8 SOUND TRAPS:

A. Sound Traps:

B. Material: Steel shell, perforated steel partitions, packed mineral or fiberglass filter material. Performance equivalent to VibroAcoustics unit scheduled on drawings. Approved suppliers: IAC, Koppers, Joy, Transonics, Aerosones, Vibro-Acoustics.

C. Installation: Sleeve wall openings, seal all around with angle iron closure. Follow with 2" of rigid insulation all around sound traps, butted tight to angle closure. Cover with canvas and seal. Refer to specifications for additional detail.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install hand operated volume dampers at locations and of sizes shown. Volume dampers shall be controlled by heavy duty locking quadrants mounted on the outside of the duct. Where ducts are insulated, the damper rod shall be extended and the operator shall be mounted on the outside of the insulation. Butterfly dampers may be constructed by the Sheet Metal Contractor. All multi-blade hand dampers shall be the product of one of the manufacturers listed in the Contract Documents. All operator fittings shall be heavy duty commercial grade.

C. Install turning vanes in square or rectangular 90 degree elbows in supply and exhaust air systems, and elsewhere as indicated.

D. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is to small for person to enter.

E. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.3 FIELD QUALITY CONTROL:

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to

obtain proper operation and leakproof performance.

3.4 ADJUSTING AND CLEANING:

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

1. Label access doors in accordance with Division 23 section "Mechanical Identification".

2. Final positioning of manual dampers is specified in Division 23 section "Testing, Adjusting, and Balancing".

3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 EXTRA STOCK:

A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

3.6 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 233300

SECTION 233423 - POWER VENTILATORS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 General Mechanical Requirements sections apply to work of this section.

C. See Section 23 05 13 Motors, Drives and Electrical Requirements for Mechanical Work.

1.2 SUMMARY:

A. Extent of power and gravity ventilator work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of power and gravity ventilators specified in this section include the following:

1. Power ventilators.

a. Roof Mounted Exhaust Fans.
b. Roof Mounted Relief Fans.

C. Refer to Division 23 section "System Commissioning, Testing and Balancing" for balancing of power and gravity ventilators; not work of this section.

D. Refer to Division 23 temperature control systems sections for control work required in conjunction with power and gravity ventilators; not work of this section.

E. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on ventilators. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

2. Interlock wiring between ventilators; and between ventilators and field-installed control devices as shown in Division 26.

a. Interlock wiring specified as factory-installed is work of this section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of power and gravity ventilators, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical data for power and gravity ventilators, including specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to power ventilators. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 23.

1.5 REFERENCES:

A. Codes and Standards:

1. AMCA Compliance: Provide power ventilators which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Rating Seal.

2. UL Compliance: Provide power ventilators which are listed by UL and have UL label affixed.

3. NEMA Compliance: Provide motors and electrical accessories complying with NEMA standards.

PART II - PRODUCTS

2.1 ROOF MOUNTED RELIEF FANS (DOME TYPE):

A. Description: Fan shall be a spun aluminum, roof mounted, belt driven, down blast centrifugal exhaust ventilator. Size and capacity as listed on the drawings.

B. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

C. Construction: The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have a rolled bead for added strength. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. Bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Unit shall bear an engraved aluminum nameplate. Hinged base.

D. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, *Balance Quality and Vibration Levels for Fans.*

E. Motor: Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure.

F. Bearings: Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball type in a cast iron housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.

G. Belts & Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

H. Furnish with insulated hinged roof curb, to raise fan 12" above roof. Compatible with roofing and roof slope. Furnish with bird screen. Exhaust fan REF-4 and 5 shall be provided with insulated sound curb.

I. Furnish with factory installed and wired isolation damper complete with electric damper actuator. Damper shall be Ruskin CD50 or Greenheck VCD43. Damper shall be mounted inside the curb and accessed thru the hinged opening between the curb and fan base.

J. Manufacturer: Subject to compliance with requirements, provide exhaust fans on one of the following:

1. Cook
2. Acme
3. Greenheck

2.2 ROOF MOUNTED EXHAUST FANS (DOME TYPE):

A. Description: Fan shall be a spun aluminum, roof mounted, belt driven, down blast centrifugal exhaust ventilator. Size and capacity as listed on the drawings.

B. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

C. Construction: The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have a rolled bead for added strength. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. Bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Unit shall bear an engraved aluminum nameplate. Hinged base.

D. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, *Balance Quality and Vibration Levels for Fans.*

E. Motor: Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure.

F. Bearings: Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball type in a cast iron housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.

G. Belts & Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

H. Furnish with insulated hinged roof curb, to raise fan 12" above roof. Compatible with roofing and roof slope. Furnish with bird screen. Exhaust fan REF-4 and 5 shall be provided with insulated sound curb.

I. Furnish with factory installed and wired isolation damper complete with electric damper actuator. Damper shall be Ruskin CD50 or Greenheck VCD43. Damper shall be mounted inside the curb and accessed thru the hinged opening between the curb and fan base.

J. Manufacturer: Subject to compliance with requirements, provide exhaust fans on one of the following:

1. Cook
2. Acme
3. Greenheck

PART III - EXECUTION

3.01 INSPECTION:

A. General: Examine areas and conditions under which power and gravity ventilators are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF POWER VENTILATORS:

A. General: Except as otherwise indicated or specified, install power ventilators in accordance with manufacturer's installation instructions and recognized industry practices to insure that products serve the intended function.

B. Coordinate ventilator work with work of walls, roof and ceilings, as necessary for proper interfacing.

C. Ductwork: Refer to Division 23 section "Ductwork." Connect ducts to ventilators in accordance with manufacturer's installation instructions.

D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted.

E. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.

F. Hang from or install on spring type vibration isolators, complete with appropriate mounting frame.

3.03 FIELD QUALITY CONTROL:

A. Testing: After installation ventilators has been completed, test each ventilator to demonstrate proper operation of unit at performance requirements specified. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

3.04 ADJUSTING AND CLEANING:

A. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.05 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 233423

SECTION 233616 - AIR TERMINAL UNITS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 SUMMARY:

A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air terminals specified in this section include the following:

1. Air Control Valves

a. Single Duct VAV Cooling only.
b. Single Duct VAV Cooling with H.W. Heating.

C. Refer to other Division 23 sections for external insulation of air terminals; not work of this section.

D. Refer to other Division 23 sections for testing, adjusting and balancing of air terminals; not work of this section.

E. Refer to other Division 23 sections for temperature controls which are to be furnished by others but installed as work of this section.

F. Refer to other Division 23 sections for temperature controls for air terminals; not work of this section.

G. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on air terminals. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects with metal ductwork systems work similar to that required for project.

1. The Installer shall have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the contractor.

2. All workmen on the project shall carry state licenses as journeymen or apprentice sheet metal workers with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Section 23 05 93.

1.5 REFERENCES:

A. Codes and Standards:

1. ARI Compliance: Provide air terminals which have been tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bear ARI certification seal.

2. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

3. International Building Code/International Mechanical Code: Comply with all sections pertaining to mechanical work.

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.

B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART II - PRODUCTS

2.1 GENERAL:

A. A VAV box controller is required which can provide a non-pneumatic, pressure independent, controls sequence.

1. Fit boxes with volume and temperature sensors and DDC controls, see Division 23 Controls.

2. Box capacity shall be equivalent to that scheduled.

2.2 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide air terminals of one of the following:

1. Titus
2. Krueger
3. Price

2.3 SINGLE DUCT VARIABLE VOLUME COOLING ONLY:

A. General: Provide factory-fabricated and tested air terminal as indicated, selected with performance characteristics which match or exceed those indicated on the schedule. Vendor/Contractor to verify count and arrangement.

B. Construction: Factory fabricate VAV damper and coil into a single cabinet. Construct cabinet of 22 gauge or heavier galvanized steel with a 1" thick acoustical lining. Construct VAV damper of air-tight, quarter turn design with shaft supported in sintered bronze or nylon bearings.

C. Controls: Furnish unit with a package control setup to accomplish the following: See Section 23 05 93. ATC contractor shall furnish box controllers and accessories and make field installation.

1. Pressure independent digital electronic controller.
2. VAV damper control, normally closed, (NC).

D. Acceptable Manufacturers:

1. Titus
2. Krueger
3. Price

2.4 SINGLE DUCT VARIABLE VOLUME COOLING WITH HW HEATING (VAVR):

A. General: Provide factory-fabricated and tested air terminal as indicated, selected with performance characteristics which match or exceed those indicated on the schedule. Vendor/Contractor to verify count and arrangement.

B. Construction: Factory fabricate VAV damper and heating coil into a single cabinet. Cabinet shall be of 22 gauge or heavier galvanized steel with a 1/2" thick acoustical lining. VAV damper shall be of air-tight, quarter turn design with shaft supported in sintered bronze or nylon bearings.

C. Controls: Furnish unit with a package control setup to accomplish the following: See Section 23 05 93. ATC contractor shall furnish box controllers and accessories and make complete installation.

1. Pressure independent digital electronic controller.
2. VAV damper control, normally closed, (NC).

D. Heating Coils: Capacity and size as scheduled. Coils minimum 1 row, 10 FPI, with 2 row, 8 FPI provided where capacity dictates.

1. Fins: Heavy gage corrugated plate sheet aluminum.

2. Tubes: Copper tube, 1/2" or 5/8" diameter, 0.016 minimum wall thickness, expand tube into fins.

3. Headers: Seamless Type K or L copper tube headers and return bends, brazed connections.

4. Casings: Construct of 20 gauge continuous coated galvanized steel with fins recessed into channels to minimize air bypass.

5. Testing: Air tested under water to 175 psig.

6. The successful supplier shall include as part of the submittal, computer generated capacity data for each coil. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410.

E. Acceptable Manufacturers:

1. Titus
2. Krueger
3. Price

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF AIR TERMINALS:

A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.

B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer. Protect electrical clearances. Protect access to controls.

C. Duct Connections: Connect ductwork to air terminals in accordance with Division 23 ductwork sections.

D. Seismic Restraint: Provide 3-dimensional restraint for all suspended boxes.

3.3 FIELD QUALITY CONTROL:

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.4 CLEANING:

A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

3.5 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 233616

SECTION 233713 - AIR OUTLETS AND INLETS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

1.2 SUMMARY:

A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.

B. Types of outlets and inlets required for project include the following:

1. Ceiling air diffusers and grilles.
2. Wall registers and grilles.
3. Louvers.

C. Refer to other Division 23 sections for ductwork and duct accessories required in conjunction with air outlets and inlets; not work of this section.

D. Refer to other Division 23 sections for balancing of air outlets and inlets; not work of this section.

E. Refer to other Division sections for louvers, not work of this section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects with metal ductwork systems work similar to that required for project.

1. The Installer shall have a publicly registered bonding capacity of sufficient amount to cover this work and all other work in progress by the Contractor.

2. All workmen on the project shall carry state licenses as journeymen or apprentice sheet metal workers with additional certification for welders.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.

2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.

B. Samples: 3 samples of each type of finish furnished.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

D. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of General Conditions.

1.5 REFERENCES:

A. Codes and Standards:

1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".

2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".

3. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".

4. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.

5. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART II - PRODUCTS

2.1 GRILLES AND DIFFUSERS:

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Adjust all grilles and diffusers to fit neatly in the room ceiling pattern. Set final locations per architectural reflected ceiling plans.

E. Volume Control Dampers: Provide duct mounted dampers of the externally adjustable opposed blade type where more than one grille or register is on a common duct. Provide access to each damper adjustment.

F. Sound Level: The diffuser or grille generated noise shall not exceed the following sound power level curve at a point five feet away form the diffuser or grille.

1. Meeting Rooms: Classrooms: NC 25-30
2. Dining Area: NC 25-30
3. Office Areas: NC 25-30
4. Kitchen Areas: NC30-35
5. Storage: NC35

G. Manufacturers: Subject to compliance with requirements, provide grilles and diffusers of one of the following:

1. Krueger
2. Titus
3. EH Price

H. Types: Provide grilles and diffusers of type, capacity, and with accessories and finishes as listed on grille and diffuser schedule and as specified herein.

I. Grilles and Diffusers:

1. Ceiling Supply Diffuser: Titus Series TMS with adjustable tubs for directional air flow control, square face, round neck, four-way deflection, anti-smudge design, removable inner core, all steel construction, appropriate mounting frame, white baked enamel finish, size as indicated on drawings.

2. Sidewall Supply Register: Titus Series 350RS steel, adjustable, double deflection blades, 3/4"maximum blade spacing, appropriate mounting frame, sponge rubber gasket, baked enamel finish, color selected by Architect, size indicated on drawings.

3. Ceiling Supply Diffuser: Titus Series MCD, square face, modular one, two three or four way blow as required. Square neck, opposed blade volume damper, anti-smudge border, all steel, white baked on enamel, size as indicated on drawings.

4. Perforated Return Register: Titus Series PAR. Concealed hinge frame, sponge rubber gasket, white baked-on enamel, size as indicated on drawing.

5. Sidewall Return Register: Titus Series 350RL. Steel construction, appropriate mounted frame, 3/4” blade spacing, blades on 35 deg. angle unless otherwise shown on drawings, sponge rubber gasket, size as indicated on drawings. Color selected by Architects.

2.2 LOUVERS:

A. Extent of Work: At air openings in the outside wall where indicated on drawings, install AMCA rated drainable stationary extruded aluminum 6" deep weather louvers.

B. Material: Blades shall be on 3-1/2" centers with integral downspouts to drain the water from the louver blades. Stationary louvers shall pass 1000 fpm free area velocity with less than 0.2" static pressure drop and shall carry less than .03 ounces of water per square foot when tested in accordance with AMCA Standard 500. Install stainless steel 1/2” mesh screens on interior face and louver.

1. Louvers shall be equal to Ruskin ELF6375DX American Warming and Ventilating LE-31, Louvers and Dampers, Krueger, Ruskin, Greeheck. Coordinate with the Architectural details for type of flange and structural details for actual wall opening sizes. Anodized aluminum finish. Finish color and type selected by Architect.

C. Contractor must coordinate louver size, flange type, and construction with structural and architectural openings to assure fit and appearance. Louvers shall be one piece.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

3.3 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 233713

SECTION 234116 - AIR FILTERS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 General Mechanical Requirements sections apply to work of this section.

1.2 SUMMARY:

A. Extent of air cleaning work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air cleaning equipment specified in this section include the following:

1. Filter Holding Systems.

a. Universal Holding Frame for field fabricated air handling systems.

b. Factory fabricated for factory fabricated air handlers.

2. Air Filters.

a. Replaceable (throwaway).

b. Extended surface self-supporting.

3. Filter Gages.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air cleaning equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data including, dimensions, weights, required clearances and access, flow capacity including initial and final pressure drop at rated air flow, efficiency and test method, fire classification, and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for filter rack assemblies indicating dimensions, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of filter and rack required. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 23.

1.5 REFERENCES:

A. Codes and Standards:

1. UL Compliance: Comply with UL Standards pertaining to safety performance of air filter units.

2. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

3. ARI Compliance: Comply with provisions of ARI Standard 850 pertaining to test and performance of air filter units.

PART II - PRODUCTS

2.1 AIR FILTERS:

A. Manufacturers: Subject to compliance with requirements, replaceable filter media and holding frames shall be a product of one of the following:

1. American Air Filter
2. Continental
3. Farr
4. Flanders/Eco Air

B. Holding Frames: Suitable for filters specified.

1. Field fabricated for built-up system - 16 gauge galvanized steel minimum. Provide stiffening pieces as required to with stand 10" pressure differential.

2. Filter bank sizes as shown on drawings.

C. Type 1: Replaceable flat media.

1. Flat panel non-woven cotton fabric in a cardboard holding frame, 1" thick. .26" s.p. initial pressure drop, to change out at 0.50", 20% average efficiency on 85% average arrestance on ASHRAE Test 52-76.

2. Equivalent to Farr 20/20 series.

D. Type 2: Replaceable pleated media type filters.

1. Pleated, medium efficiency in a cardboard holding frame, 2" thick as scheduled, 0.32" s.p. maximum initial pressure drop at 500 feet/minute, to change out at 0.50". U.L. Class 2, 25-30% efficiency, 90-95% arrestance per ASHRAE Standard 52-76.

2. Equivalent to Farr 30/30.

E. Filter Gauges:

1. Magnehelic Gauge 0-1" range for flat filters, 0-3" range for high efficiency rigid or lag filters, other gauges to match filter range.

2. Furnish with mounting bracket, pressure tips, tubing vent/zero valves.

F. Startup Set:

1. Install a set of Type 2 filters immediately upon fabrication of any filter bank. Install scheduled set of filters at completion of construction at the time of testing and balancing. Second set for replacement at the end of the job.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air filters and filter housings will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. General: Comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.

B. Install air filters and holding devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes. Filter to be positioned so as air flow pushes filter into frame.

C. Locate each filter unit accurately in position indicated, in relation to other work. Position unit with sufficient clearance for normal service and maintenance. Anchor filter holding frames securely to substrate, with spring attachment, provide second spring attachment and seal assembly to fasten prefilter to face of final filter.

D. A vertical galvanized metal strip 2" wide and of a gauge equal to the filter frame shall be installed between each and every filter column to increase bank rigidity.

E. Coordinate with other work including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.

F. Install filters in proper position to prevent passage of unfiltered air.

G. Install air filter gage pressure tips upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gages if any, for proper readings.

H. Install 1" sheetmetal strip in bottom of each filter frame. Sheetmetal strip to have upturned ends to allow for easy removal of filter media.

3.3 FIELD QUALITY CONTROL:

A. Operate installed air filters to demonstrate compliance with requirements. Test for air leakage of unfiltered air while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with retesting.

3.4 EXTRA STOCK:

A. Provide two sets of filters: one for start-up/balancing use; the second for replacement at the end of the job.

3.5 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 234116

SECTION 235234 - BOILERS

PART I GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including general and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. All pertinent sections of Section 23 00 00 - General Mechanical Requirements are a part of the work described in this section.

C. Related Sections:

1. Refer to other sections of Division 23 for piping, specialties, pumps, valves, field-installed automatic temperature controls, and field applied insulation.

1.2 SUMMARY:

A. Includes But Not Limited To:

1. Furnish and install the following boilers as described in the Contract Documents.

a. Packaged natural gas-fired heating water boiler of the size and capacity specified.

1.3 SYSTEM DESCRIPTION:

A. Heating Water Boiler.

B. Boiler shall be constructed, assembled, and delivered as a completely packaged unit.

C. Boiler Management System Control Panel.

1.4 QUALITY ASSURANCE:

A. Codes and Standards:

1. Boiler shall be AGA certified and have IBR approved ratings.

2. Bearing ASME stamp for working pressure of 160 psi working pressure.

3. UL listed and so labeled burner and controls.

4. Local Boiler Code

1.5 SUBMITTALS:

A. Submit shop drawings and product data.

B. Include boiler and burner manufacturer installation instructions.

C. Submit boiler and burner manufacturer descriptive literature, operating instructions, and maintenance instructions.

D. Provide boiler permit and inspection by State of Utah Boiler Inspection Division.

1.6 WARRANTY: The pressure vessel of boiler shall carry an unconditional, non-prorated 10 year warranty against leakage due to defective materials or workmanship. The heat exchanger tubes/combustion chamber assembly shall be warranted against failure due to thermal stress failure or condensate corrosion for a prorated five year period. A Warranty Certificate must be issued to the contracting officer from the manufacturer and a copy of warranty be submitted for the Owner's approval.

1.7 FIELD SERVICES: Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment start-up. A letter of compliance with all factory recommendations and installation instructions shall be submitted to the contracting officer with operation and maintenance instructions.

PART II PRODUCTS

2.1 BOILER

A. The water containing section shall be of a high efficiency copper finned design, with straight copper tubes having extruded integral fins spaced approximately seven fins per inch. The tubes shall be set vertically and securely into lined, headers forming the top and bottom of the heat exchanger. The heat exchanger shall be circular in pattern and shall completely enclose the combustion chamber for maximum efficiency. There shall be removable access covers on the heat exchanger headers for the purposes of inspection, cleaning or repair. The heat exchanger shall have externally accessible boiler drains. The heat exchanger shall be mounted in a stress free jacket assembly in order to provide a free floating design able to withstand the effects of thermal shock. The Boiler shall bear the ASME stamp for 160 PSI working pressure and shall be national Board listed. The complete heat exchanger assembly shall carry a ten (10) year warranty against failure caused by defective workmanship or material.

B. The combustion chamber shall be of the sealed combustion type. The burner surface shall be constructed of high temperature stainless steel and fire in a vertical plane within the combustion chamber. The burner shall employ a special perforated flame injection tube extending the entire length of the exchanger. The burner shall fire in a full 360 degree pattern resulting in uniform heat transfer upon every inch of heating surface. An external viewing port shall be provided, permitting visual observation of burner operation.

C. The hot water Boiler shall use a combustion air blower to precisely control the fuel/air mixture for maximum efficiency. The combustion air blower shall operate for a pre-purge period before burner ignition and a post-purge period after burner operation to clear the combustion chamber. Outside air intake duct shall be single wall, size as recommended by the manufacturer, and be provided with a rainproof intake cap with 1/4" insect screen

D. The Boiler shall be constructed with a 16 gauge galvanized steel jacket assembly. All steel jacket components must be galvanized on both sides. The interior of the combustion chamber and flue collector shall be lined with a corrosion resistant polymer coating. All inner and outer jacket panels shall be fully gasketed and sealed. The exterior of the jacket assembly shall be finished in a 3-coat acrylic enamel finish.

E. The Boiler shall be vented with a vertical positive draft, Category II, double wall, AL29-4C vent system. Provide windproof vent termination as recommended by the boiler manufacturer.

F. Provide windproof vent termination as recommended by the below manufacturers. The Boiler shall be certified and listed by The American Gas Association under the latest edition of the ANSI Z21.13 test standard. The Boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The Boiler shall be certified and listed in Canada by The Canadian Gas Association under the latest edition of standards CAN1-3.1 and CSA C22.2. The Boiler shall operate at a minimum of 88% thermal efficiency.

G. Operating controls shall include an adjustable immersion type temperature controller and an immersion safety high limit to regulate boiler water temperatures. Multiple air pressure switches shall be provided to prove operation of the combustion air fan, monitor combustion chamber pressures and monitor operation of the flue.

H. Control system shall include an electronically proven Hot Surface Ignition system with full flame monitoring capability. Manually operated gas plug cock, multiple main gas valves and built in low gas pressure regulator shall be supplied. A low gas pressure switch shall monitor gas supply. Additional controls shall include a low voltage transformer for the control circuit, a flow switch to prove water flow, inlet and outlet temperature gauges, and a factory installed ASME pressure relief valve. The manufacturer shall verify proper operation of the burners, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping. A quality test report shall be shipped with each unit.

I. The units control panel shall contain a lighted on/off main power switch, pilot lights to indicate proper operation and diagnostic pilot lights to indicate control sensed malfunctions. A 24 VAC control circuit and components shall be used. All components shall be easily accessed and serviceable from the front and top of the unit. All wiring harness connections shall have multi-pin plug in type connectors to ease service, troubleshooting and reduce removal and replacement cost. Coordinate with the controls contractor to provide alarms and operation parameters for the DDC system.

J. Gas train components to meet the requirements of Factory Mutual (FM). Boiler to be provided with a manual reset high limit, flow switch and vent line connection points. A downstream leak test cock to be provided. All components factory mounted and wired.

K. Size and capacity as indicated on the drawings.

L. Approved Manufacturers -

1. Thermal Solutions - Evolution
2. Lochinvar - Power Fin

3. RBI – Futura III

2.2 ACCESSORIES

A. Multiple Unit Discharge Water Control shall be provided. Controller shall be full modulating or have a capacity for two to six stages of control. The control system shall provide:

1. Field adjustments setpoint from 80ºF to 220ºF
2. Field adjustable reset ratio from 1:4 to 4:1
3. Field adjustable control band for 2 to 16ma
4. Field adjustable outdoor air reset start point from 80ºF to 40ºF
5. Field adjustable number of stages input from 1 to 6 stages or full modulation
6. Proportional plus integral plus derivative temperature control loop (PID)
7. LED stage indication lights on exterior of panel
8. Remote setpoint capability
9. Platinum discharge water sensor
10. Thermistor type rest sensor
11. Soft start control algorithm
12. Field adjustable lead/lag or 1st on last-off sequencing
13. Minimum on/off and delay between stages timing sequence
14. Night setback setpoint with a time clock contract closure
15. NEMA-1 enclosure with a key locking door
16. Internally wired transformer, 120 VAC power supply to panel
17. Terminal strips provided for all field wiring connections

B. Barometric Damper for each Boiler

PART III - EXECUTION

3.1 INSTALLATION OF BOILER:

A. General: Install boiler(s) in accordance with manufacturer’s installation instructions, in accordance with State and local code requirements, and in accordance with requirements of

local Utility Company. Install the unit(s) plumb and level. Maintain manufacturer's recommended clearances around and over the boiler(s).

B. Support: Install boiler(s) on 4" thick concrete pad, 4" larger on each side than base of unit. Anchor boiler per seismic requirements.

C. Erection: Assemble heater trim shipped loose, or unassembled for shipment purposes. Follow manufacturer's installation instructions.

D. Electrical Work: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Contractor.

1. Verify that electrical work installation is in accordance with manufacturer=s submittal. Do not proceed with equipment start-up until electrical work is acceptable.

E. Boiler Trim: Install boiler trim and devices furnished with boiler but not factory-installed.

F. Gas Piping: Refer to Division-23 section Natural Gas Systems. Connect gas piping to boiler, size as indicated, provide union with sufficient clearance for burner removal and service.

G. Hot Water Piping: Refer to Division-23 section Hydronic Piping. Connect supply and return boiler tappings as indicated, with shutoff valve and union or flange at each connection.

H. Breeching: Refer to Division-23 section Ductwork. Connect breeching flue to boiler outlet, full size of outlet. Route as directed.

3.2 FIELD QUALITY CONTROL:

A. Flush and clean boilers upon completion of installation, in accordance with manufacturer's start-up instructions.

B. Start-up boilers, in accordance with manufacturer's start-up instructions, and in presence of boiler manufacturer's representative. Test controls and demonstrate compliance with requirements. Adjust burner for maximum burning efficiency. Replace damaged or malfunctioning controls and equipment. Notify the Owner's Representative seven working days in advance of start-p. Provide report of start-up to the Owner.

3.3 CLOSEOUT PROCEDURES:

A. Participate in instruction of government personnel during the O&M training specified in Section 23000

3.4 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 235234

SECTION 23 64 11 - AIR COOLED PACKAGED CHILLER

PART I - GENERAL

1.1 WORK INCLUDED:

A. Air cooled chiller package.

B. Controls and control panel.

1.2 SUBMITTALS:

A. Submit shop drawings and manufacturer's product data.

B. Show on shop drawings equipment, piping connections, valves, strainers, and thermostatic valves required for complete system.

C. Submit certification that related components not furnished by chiller manufacturer have been selected in accordance with his requirements.

D. Submit manufacturer's installation instructions.

PART II - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Acceptable Manufacturers:

1. Carrier.
2. Trane.
3. York.

2.2 AIR COOLED PACKAGE CHILLER:

A. LIQUID-CHILLING PACKAGE; SCROLL, OR SCREW:

1. General: The unit shall be designed, fitted, factory tested, and rated in accordance with ARI 550/590. The unit shall also meet all the requirements of ASHRAE 15. Entire unit shall be factory assembled, completely piped and wired except for units with remote condensers. Single packaged units shall be charged with refrigerant and oil ready for operation after connection to utilities. The unit shall include the following components as defined in paragraph SYSTEM COMPONENTS:

   a. Refrigerant and Oil

   b. Scroll or Helical Rotary Screw Compressor

   c. Compressor Driver, Electric Motor

   d. Compressor Driver Connections

   e. Liquid Cooler

   f. Integral Air-Cooled Condenser

   g. Receivers

   h. All customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment

2. Capacity Criteria: The unit shall have a minimum ARI Energy Efficiency Ratio (EER) of 9.7 and a minimum Integrated Part Load Value (IPLV) of 12.6 in accordance with ARI 555/590.

3. Controls Package: Each water-chilling unit shall be provided with operating and safety controls of the electric or electronic type. The Contractor shall properly coordinate the chiller control system with the temperature-control system specified in Section 23 09 23 DIRECT DIGITAL CONTROL. Temperature sensing elements shall be located as recommended by the manufacturer and as shown on the drawings. Capacity reduction may be provided by sequence operation of two or more, but shall not exceed four compressors per circuit, or by a combination of both methods. Each unit shall be provided with a factory-piped and -wired control panel fitted with:

   a. A refrigerant discharge pressure and suction pressure gauge

   b. A separate high-pressure cut-out with manual reset

   c. A low-temperature cutout

   d. Compressor operating control

   e. Entering and leaving chilled water cutout

   f. Operating pilot light

   g. Any other relays or appurtenances necessary for safe, controlled chiller operation

   h. Manual auto on-off switch. Provide circuit breaker or disconnect as recommended by the manufacturer. Also provide a convenience outlet.

   i. Alarm circuit terminals to actuate a minimum 100 mm (4 inch) diameter alarm bell in the event of machine cutout on any protective device, except when the low-pressure control is used as an operating control. Transformer for the bell circuit requiring low voltage shall be provided by the Contractor. Oil pressure gauge and low oil pressure cutout shall be provided on compressors which utilize positive displacement type oil pumps.

   j. System capacity control, pressure or temperature actuated, on systems over 3.5 kW (10 tons) to adjust the unit capacity in accordance with the system load, and to automatically re-cycle the system on power interruption.

4. Base: Unit shall be mounted on a structural steel or cast iron base. Compressors shall be mounted on vibration isolators.

5. Refrigerant Circuit: Each circuit shall include combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve, thermostatic expansion valve with external equalizer, and superheat adjustment.

6. Refrigerant and Oil: All refrigerants shall be one of the fluorocarbon gases, either R-22 or R-134a, and be in accordance with FS BB-F-1421. The unit shall be factory leak tested and dehydrated. Where factory does not pre-charge the system, Contractor shall provide and install a complete charge of refrigerant and oil required for the installed system as recommended by the manufacturer.

B. COMPRESSOR(S):

1. Scroll Compressor(s): Compressors shall be of the compliant, hermetically sealed design. Compressors shall be mounted on vibration isolators to minimize vibration and noise. Rotating parts shall be statically and dynamically balanced at the factory to eliminate vibration. Lubrication system shall be centrifugal pump type equipped with an oil level bull's eye sight glass and an oil charging valve. Crankcase oil heater shall be provided if standard or if available as an option. If provided, the crankcase oil heater shall be controlled as recommended by the manufacturer.

2. Helical Rotary Screw Compressor(s): Compressors shall operate stably for indefinite time periods at any stage of capacity reduction without hot-gas bypass. Provision shall be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Helical rotary screw compressors shall include:

   a. An accessible, hermetic, positive displacement, oil-injected design directly driven by the compressor driver.

   b. Rotors which are solid steel forging with sufficient rigidity for proper operation.

   c. A maximum rotor operating speed no greater than 3600 RPM.

   d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors.

   e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

   f. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with AFBMA 9 or AFBMA 11. Bearings shall be conservatively loaded and rated for an L(10) life of not less than 200,000 hours.

   g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

   h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide automatic capacity modulation from 100 percent to 15 percent.

   i. An external oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

   j. Crankcase oil heaters controlled as recommended by the manufacturer.

C. COMPRESSOR DRIVER, ELECTRIC MOTOR: Motor starter shall be unit mounted. The compressor(s) shall be driven by an electric motor that has a maximum speed of 3,600 rpm. Motor shall be of the constant-speed, squirrel-cage induction, open enclosure, or hermetically sealed, normal- or high-torque type as required by the compressor manufacturer to adequately bring the compressor up to full operating speed without damaging the equipment. Motor shall be furnished with magnetic across-the-line or reduced-voltage motor starter as required by the unit manufacturer to limit unit total instantaneous-current flow during start-up to a maximum of 125 amps. Motor starter shall be provided with NEMA 3R enclosures with an integral circuit breaker which trips the breaker when the starter door is opened. Hermetically sealed motors shall be refrigerant-gas cooled. Wiring shall be as recommended by the compressor manufacturer to provide completely automatic operation of the system. Motors shall be protected against running overload and motor-winding temperature overloads. All compressors shall be protected from rapid on-off cycling by a 20-minute time-delay switch initiated by unit shutdown with an adjustable time delay. Motor controller shall be suitable for starting compressor motor intermittently at 5 minute intervals continuously without damage to controller.

D. COMPRESSOR DRIVER CONNECTIONS: Each compressor shall be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives shall be designed for not less than 150 percent of the driving motor capacity. Flexible couplings shall be of the type that does not require lubrication. Each machine driven through speed-increasing gears shall be so designed as to assure self-alignment, interchangeable parts, proper lubrication, and minimum of unbalanced forces. Bearings shall be of the sleeve or roller type. Pressure lubrication with pump and cooler shall be provided. Gear cases shall be oil tight. Shaft extensions shall be provided with seals to retain oil and exclude all dust.

E. LIQUID COOLER: Liquid coolers shall be designed, fitted, and rated in accordance with ARI 550/590. Coolers shall be designed, constructed, tested, and certified in accordance with ASME-16 as applicable, and shall comply with the provisions of ASHRAE 15. Liquid coolers shall be designed for waterside working pressures not less than 1000 kPa (150 psig). On direct-expansion- type units, refrigerant circuit shall be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading. Liquid coolers shall be of the removable or fixed-tube bundle type except that units less than 77 kW (20 tons) may be coaxial-tube type. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Nominal tube thickness shall be no less than 0.71 mm (0.028 inches). Each tube shall be individually replaceable, excluding the coaxial-tube type. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be carbon mild steel properly spaced to provide adequate tube support, and cross flow liquid cooler feed control shall be complete and designed to feed the cooler at all levels of capacity from 100 percent down to minimum required operating level. Performance shall be based on a water velocity not less than 0.91 m/s (3 fps) nor more than 3.7 mm (12 fps) and fouling factor of .0001 sq. ft.-hour-degree F/btu.

F. Condenser(s)

1. Air-Cooled Condenser and Condensing Section:

a. Sizing: Sizing of the condenser for full capacity at design conditions shall be based on the temperature difference between the entering outside air and the condensing refrigerant for systems with stand-alone condensers that are not part of a manufacturer matched combination and cataloged system. Sizing of all other condensers for full capacity at design conditions shall be based on a maximum of 16.7 degrees C (30 degrees F) temperature difference between the entering outside air and condensing refrigerant.

b. Construction: Air-Cooled condenser shall be designed, fitted, tested, and rated in accordance with ARI 210/240, ARI 365, ARI 460, or ARI 590 as applicable and shall meet the requirements of ASHRAE 15. Condenser shall be an integral part of the liquid-chilling package unit. Air-cooled condenser shall be a complete factory- fabricated and assembled unit, consisting of coils, fans, and electric-motor drive. Unless the condenser coil is completely protected through inherent design, screens shall be provided by the manufacturer to prevent physical damage to the coil.

c. Operation: Saturated refrigerant condensing temperature shall not be over 55 degrees C (130 degrees F) unless the system can meet the unit efficiency specified on the drawings at the provided condensing temperature, in which case the manufacturer shall certify that the condenser and associated equipment is designed for the submitted condensing temperature. The saturated condensing temperature shall not exceed 63 degrees C (145 degrees F) in either case. Entering dry bulb outside design air temperature shall be as indicated. For those periods when the refrigeration system will operate over design conditions, the equipment shall be capable of operating continuously at 5.6 degrees C (10 degrees F) above stated outside design air temperature without damage or shutdown of the compressor motor or shutdown of the refrigeration system by safety devices.

d. Condenser Coil: Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper tubes with compatible copper fins. On condensers with all aluminum construction, tubes shall conform to ASTM B 210, alloy 1100, and aluminum alloy conforming to chemical requirements of ASTM B 209, alloy 7072 shall be used for the fins and end sheets. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coil shall be tested after assembly at pressure specified in ASHRAE 15 for the refrigerant employed in the system.

e. Fans: Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced.

f. Condenser Casing: Condenser casing shall be aluminum not less than 2 mm (0.080 inch) or hot-dip galvanized steel not lighter than 18-gauge. Vibration isolators provided shall be a standard catalog product with published loading ratings. Isolators shall be guaranteed to limit vibration transmission to 20 percent at lowest equipment rpm.

g. Refrigerant Storage: Air-cooled condenser may be used for refrigerant storage in lieu of a separate receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for packaged air-cooled chillers and air-cooled condensing units with field installed refrigerant piping no longer than recommended by the manufacturer; 20 percent for all air-cooled condensers; and 20 percent for all air-cooled condensing units with field installed piping which is longer than recommended by the manufacturer.

h. Condenser Controls: If the equipment or system served by the condenser requires control of head pressure either air volume head pressure control or condenser flooding head pressure control shall be provided which meets the following requirements:

(1) Air Volume Control: On a decrease in refrigerant discharge pressure, volume-control dampers shall modulate to control the airflow over the condenser coil. Solid-state variable-speed fan motor controller may be provided in lieu of volume dampers to control the air flow over the coil. Condensers with multiple fans may be provided with fan cycling control to cycle fans in response to outdoor ambient temperature. Control shall be set for minimum of 35 degrees C (95 degrees F) saturated refrigerant condensing temperature.

(2) Condenser Flooding: On a decrease in refrigerant discharge pressure, a head pressure sensitive valve shall throttle condenser outflow to increase the amount of liquid in the condenser. A differential pressure hot-gas bypass valve shall be provided to maintain receiver pressure which opens as the receiver pressure falls. Control shall be set for minimum of 35 degrees C (95 degrees F) saturated refrigerant condensing temperature.

(3) Condenser shall be provided with a low ambient temperature control package which permits the compressor to start and run and the head pressure be maintained at ambient temperatures down to minus 18 degrees C (10 degrees F)

PART III - EXECUTION

3.1 INSTALLATION:

A. Install chiller package on concrete pad in accordance with manufacturer's instructions and seismically anchor per Section 23 05 48.

B. Provide isolators between unit and support to dampen vibration transmission.

3.2 START-UP:

A. Supply initial charge of refrigerant and oil.

B. Supply service of factory trained representative for a period of one day per chiller to supervise testing, dehydration, and charging of unit(s), start-up, and instruction on operation and maintenance to Contracting Officer.

3.3 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 236411

SECTION 237300 - PACKAGED AIR HANDLING EQUIPMENT

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Motors Drives and Electrical Requirements for Mechanical Systems, General Mechanical Requirements, and General Pipes and Fittings sections apply to work of this section.

1.2 SUMMARY:

A. Extent of air-handling unit work is indicated on drawings, schedules, and by requirements of this section.

B. Types of packaged air-handling units specified in this section include the following:

1. Indoor draw-through.
2. Makeup Air Unit
3. Blower Coil Unit

C. Refer to other Division 23 sections for vibration control units used in conjunction with air handling units; not work of this section.

D. Vibration control units required for air handling units is specified in other Division 23 sections, and is included as work of this section.

E. Refer to other Division 23 sections for field-applied insulation to air handling units.

F. Refer to other Division 23 sections for hot and chilled water, and condensate drain piping required in conjunction with packaged air handling units.

G. Refer to Division 23 sections for the following work.

1. Power supply wiring from power source to power connection on unit. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed.

2. Interlock wiring between electrically-operated equipment units; and between equipment and field-installed control devices shown on electrical drawings.

a. Interlock wiring specified as factory-installed is work of this section.

H. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels.

a. Control wiring specified as work of Division 23 for Automatic Temperature Controls is work of that section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged air-handling units with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: A firm with at least 3 years of successful installation experience on projects with metal ductwork systems work similar to that required for project.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, gages and finishes of materials, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, required clearances, construction details, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals; in accordance with requirements of Division 23 05 93.

1.5 REFERENCES:

A. Codes and Standards:

1. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.

2. ARI Compliance: Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air Handling Units", display certification symbol on units of certified models.

3. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

4. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

5. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

6. International Building Code/ International Mechanical Code: Comply with all sections pertaining to mechanical work.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle air-handling units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.

C. Store air-handling units in clean dry place and protect from weather and construction traffic. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

D. Comply with Manufacturer's rigging and installation instructions for unloading air handling units, and moving them to final location.

PART II - PRODUCTS

2.1 FACTORY ASSEMBLED AIR HANDLING SYSTEM:

A. General: Provide factory-fabricated and factory tested air handling units as indicated, of sizes and capacities as scheduled, and as specified herein.

1. Air Handling Systems:

Each system shall be factory-assembled by a single manufacturer, except for those items requiring field installation such as temperature control components.

Each system shall be mounted on a common channel frame.

Each system shall be prime coated inside and out prior to any insulating and finished with a baked-on enamel finish.

Provide access doors to service all internal components. Where unit sizes are large enough, access doors shall be of a size capable of allowing a man to pass through. Each door shall have a minimum of 2 or more heavyduty hinges and 2 or more handle latches.

Doors shall be operable without the aid of any tools. Each door shall seal air tight with a continuous sponge rubber gasket.

The final responsibility for a complete and operable system lies with the mechanical contractor. This contractor shall coordinate the efforts of the equipment supplier and subcontractors to insure that final systems are complete.

Refer to drawings and specifications for capacities and additional detail.

B. Manufacturer: Subject to compliance with requirements, provide air handling units of the following:

1. Temtrol
2. Haakon
3. Pace

C. Equipment:

1. Plenum section(s): That portion of the unit which houses fans, filters, mixing sections, etc., or a blank section. These sections shall be double wall, fully lined with 2" thick 11/2 lb density fiberglass insulation. The fiberglass shall be glued and fastened to the cabinet wall with stick clips. Provide hinged access doors with quick-release handles and neoprene gaskets to all internal components. Do not use sheet metal screws for panel fasteners. The unit shall be as arranged on the drawing. Prime coat the entire unit shall be prime coated inside and out prior to insulation, then finished in a baked-on enamel finish. Mount all sections on common channel iron frame. Cabinets shall be constructed of not lighter than 16 gauge steel.

2. Fan section: AF Centrifugal Plenum fan shall be of medium pressure design and construction. Each fan shall be statically and dynamically balanced, double width, double inlet with fan wheels as noted. The motor and drive shall be mounted internal to the unit with the fan on a common spring isolated frame. Provide factory-installed seismic restraints at each corner of the isolated fan and motor frame (4 required per fan). The spring-type vibration isolators shall have a minimum of 1-1/2" deflection under operating condition. Provide a flex connection between the fan discharge and the cabinet supply collar. Drive shall be v-belt with variable pitch sheave. See Section 23 05 03. Provide extension tubes with zerk fittings to all bearings. Access doors shall be located on both sides of the unit. The supply fan section shall have the capacity to supply the scheduled cfm at the scheduled static pressure. The fan/motor combination shall come up to speed in 10 seconds or less. Provide fans by New York Blower, Chicago Blower, Buffalo.

3. Filter section: Shall house Type 2, 4" 30/30 filter in holding frame. Access doors on both sides of section. Provide two sets of filters See Section 23 41 16.

4. Cooling coil: See Section 23 82 16.

5. Heating coil: See Section 23 82 16.

6. Mixing damper section: Outside air dampers and return air dampers are remote mounted.

2.2 COIL DRAIN PANS:

A. Coil Drain Pans: Provide stainless steel, IAQ compliant, coil drain pans. Set coil into pans to catch all drips. Extend drain outlet to outside cabinet.

2.3 MAKE-UP AIR UNIT:

A. General: Provide packaged evaporative cooling and natural gas heat make-up air unit(s). Unit shall be self-contained and weatherproof. Unit components shall include but not be limited to single shelf construction, blow-through supply fan, indirect natural gas fired heating section, factory fabricated discharge plenum, filter bank, factory controls. Single point electrical connection. All mounted on a common base and frame, with field installed remote control panel.

B. The unit shall be designed for 80% thermal efficiency with power-vented gas furnaces, fabricated arranged for roof mounting on a field-assembled curb. The units are to be arranged for factory downturn plenum supply connection at discharge.

C. The units are to include a centrifugal blower, open drip-proof, energy efficient, blower motor, and an adjustable belt drive, filter rack with 2" pleated filters. Include all required

controls.

D. All units shall be equipped for use with natural gas, 460/3/60 supply voltage, 24-volt control transformer, automatic power venter, motor starter, electrical disconnect, intermittent spark pilot with timed lockout and an electric fully modulating with duct stat and remote temperature selection gas control system. (Similar to Reznor AG-9.)

E. The following accessories shall be provided: Convenience outlet, air proving switch, high ambient burner cutoff, firestat(s), remote console with required lights and switches, remote console shall have On/Off control switch, Heat/Vent/Cool switch, blower on, burner on, cool on indicating lights, and remote temperature selector ("Maxitrol"), (Similar to Reznor RC-7), downturn plenum, and 2-position control damper.

F. The duct furnace incorporated into the packaged heating and make-up air units shall be design-certified by the American Gas Association and bear the A.G.A. label.

G. Heater Section: Heater section shall be integral with air handler casing. Heaters shall be gas fired. AGA listed and provided 100% shutoff with continuous retry, automatic pilot ignition. 20 gauge minimum 409 stainless steel heat exchanger, and U.L. listed electrical components. Burner box assembly shall be completely removable for servicing and cleaning. Burner manifold piping is to include a ground joint union to facilitate easy removal of the burner box assembly. Gas controls shall have easy access and be designed for use with natural gas and rated for a maximum inlet pressure of ½ PSI. Provide with gas pressure regulator (reducing valve) to reduce from building service inlet pressure down to required unit operating gas pressure. Provide electrical modulating control system, pilot is spark ignited. Modulation range is between 40% and 100% fire; gas control shuts off below 40% fire.

H. Electrical: Provide a single point electrical connection of unit with NEMA 3R or NEMA 12 power panel with locking cover. Panel shall have a through-the-door main disconnect switch. Panel shall contain the required control power transformer(s), fuses, fuse clips, numbered terminal strips and NEMA rated magnetic starters with overload protection in each phase for all three phase motors. The high to low voltage transformer shall be provided to power control circuits. All primary and secondary transformer circuits shall be fused as required by the NEC. Single phase motors shall have a NEMA rated magnetic starter. All wiring in the unit shall be run in metal conduit or liquid tight (3 foot maximum) with raintight fittings. The above items shall be completely installed and wired at the factory according to the NEC and local codes. Provide main hand-off-auto switch.

I. Provide with factory fabricated 16" high roof curb to match unit. Field assembled.

J. Control: Unit shall be provided complete with factory furnished and installed controls to accomplish the following:

1. Electronic modulating make-up air systems with an electronic modulating control system, a duct sensing system, and a set of inlet air dampers. With the sensing probe of the duct sensing system placed in the discharge air stream to sense the discharge air temperature in the heating mode, if the discharge air temperature is lower than the set point of the modulating-regulator valve, the sensing probe will send a signal to the modulating valve(s) and low fire will begin. Low fire is 50% of full-rated input. If this firing rate is not sufficient to achieve the desired temperature, the valve(s) will continue to open and allow firing rates between 40% and 100% of full rated input until the discharge air temperature is satisfied. The setpoint of the discharge air temperature is manually adjusted at the remote control panel.

2. For a two burner section system, firing shall begin with the first modulating section.

As the first section comes to full fire, the second section shall ignite at 100% and the first section return to modulation at its minimum, then increase with demand to full firing of both sections. On a decrease in demand, the reverse function shall occur.

3. The inlet air damper is of the two-position type, either open or closed. It is always open whenever power is supplied to the make-up air unit (fan on). If power is interrupted, the damper will return to the closed position.

4. The blower also runs continuously on either high or low speed as selected as long as power is supplied to the make-up air unit (fan on).

5. The evaporative cooling pump runs whenever the evaporative cooling switch is in the on position.

6. For each unit provide a factory fabricated control panel with indicating lights, as previously described herein.

K. Manufacturer: Subject to compliance with requirements provide makeup air units of one of the following:

1. Reznor
2. Modine
3. Hastings

L. Capacity: Capacity and performance as listed on the drawings.

2.4 FAN COIL UNITS:

A. Performance Data

1. Unit capacities are certified under Industry Room Fan-Coil Air Conditioner Certification Programs in accordance with ARI Standards 440-97. Safety: All standard units shall be listed.

B. Construction

1. Concealed/Recessed Unit: The unit shall include a chassis, coil(s), fan wheel(s) fan casing(s), fan board and motor(s). Unit shall include a noncorrosive, ABS main drain pan, positively sloped in every plane and insulated with closed-cell insulation. All horizontal units shall include a thermoplastic auxiliary drain pan. Steel parts exposed to moisture shall be galvanized. The fan board assembly shall include a quick-disconnect motor plug. The chassis construction shall be 18 gauge galvanized steel, and shall be continuous throughout the unit. The unit shall be acoustically and thermally insulated with closed- cell insulation. Exposed panels on recessed units shall be 18-gauge steel construction and ship separate from the unit. Bottom panels on horizontal recessed models shall ship standard with tamperproof screw fasteners and a safety chain. All panels are made rigid by channel forming.

2. Fans: The aluminum fan wheels shall be centrifugal forward-curved and double-width. Fan wheels and housings shall be corrosion resistant. Fan housing construction shall be formed sheet metal.

3. Motors: All permanent split capacitor motors shall be run tested in assembled units. All motors shall have integral thermal overload protection and be permanently lubricated. Motors shall be capable of starting a 78 percent of rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors shall be able to operate up to 10 percent over voltage.

4. Coils: All water coils shall be burst tested at 450 psig (3,103kPa) (air) and leak

tested at 100 psig (690 kPa) (air under water) Maximum main coil working pressure shall be 300 psig (2,609kPa). Maximum entering water temperature shall be 200°F (93 C). Tubes and u-bends shall be 3/8" (10mm) OD copper. Fins shall be aluminum and shall be mechanically bonded to the copper tubes. Coil subouts shall be 5/8" (16mm) OD copper tubing. Aluminum fins shall be no lower than 2.5 m (.098")

5. Filters: Filters shall be concealed form sight and easily removable. Filters shall be located behind an integral access door on horizontal type units. Filters shall be 1" (25mm) pleated media throwaway. Pleated media filters shall be Farr 30/30.

C. Unit Leveling and Drain line Pitch: Set unit level by checking the casing. Ust a drain line pitch of 1" (2.5 cm) drop per 10 feet (3m) where possible.

PART III - EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which air-handling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF AIR-HANDLING UNITS:

A. General: Install air-handling units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.

B. Coordination: Coordinate with other work, including ductwork, floor construction, roof decking, piping, and electrical as necessary to interface installation of air-handling units with other work.

C. Access: Provide access space around air handling units and small cabinet fans for service as indicated, but in no case less than that recommended by manufacturer.

D. Support: Install floor-mounted air handling units on 4" high reinforced concrete pad, 4" larger on each side than unit base. Hang or support horizontal small cabinet unit from structure with spring hangers with seismic bracing.

E. Mounting: Mount air handling units on vibration isolators, in accordance with manufacturer's instructions.

F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

G. Piping Connections: Refer to Division 23 HVAC sections. Provide piping, valves, accessories, gages, supports, and flexible connectors as indicated.

H. Duct Connections: Refer to Division 23 Air Distribution sections. Provide ductwork, accessories, and flexible connections as indicated.

I. Grounding: Provide positive equipment ground for air-handling unit components.

J. Coil Condensate Drain Trap: Provide coil condensate drain trap of proper size and depth for each air handling unit coil condensate drain pan.

3.03 FIELD QUALITY CONTROL:

A. Testing: Upon completion of installation of air-handling units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.

B. If specified conditions cannot be obtained due to deficiencies in equipment performance or improper installation or workmanship, the Mechanical Contractor and his subcontractors shall make any changes necessary to obtain the specified conditions.

3.04 EXTRA STOCK:

A. Provide two complete sets of filters for each air handling unit. Install one set of filters at completion of air handling system work, and the other set prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

B. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.

3.05 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 237300

SECTION 238200 - TERMINAL HEAT TRANSFER UNITS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Motors Drives and Electrical Requirements for Mechanical Systems, General Mechanical Requirements, and General Pipes and Fittings sections apply to work of this section.

1.2 SUMMARY:

A. Types of terminal units required for project include the following:

1. Cabinet heater, heating water.
2. Unit heater, heating water.

PART II - PRODUCTS

2.1 CABINET HEATERS:

A. General: Provide cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, filter rails, motor, electric junction box and insulation.

B. Chassis: Galvanized steel wrap-around structural frame with edges flanged. Configuration as indicated on drawings.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: 16-ga removable front panel. Insulate front panel over entire coil section. Provide access door on coil connection side and for motor control. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer.

E. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 200 psi and leak test at 300 psi under water. Provide same end connections for supply and return. Each element shall have manual air vent.

F. Fans: Provide centrifugal, forward curved double width fan wheels. Construct fan scrolls of galvanized steel.

G. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit. Motors shall be permanently lubricated.

H. Motor Speed Control: Solid state, multi-speed with "off" position, unit mounted.

I. Filters: Provide 1" thick throwaway type filters in fiberboard frames.

J. Controls: Furnish unit with factory mounted fan speed switch and aquastat. Set up for field mounting of control valve, isolation valves, balance valve, and DDC control.

K. Unit color to be as selected by Architect. Furnish paint samples for selection.

L. Manufacturer: Subject to compliance with requirements, provide cabinet heaters of one of the following:

1. Airtherm Mfg. Co.
2. Dunham-Bush, Inc.
3. McQuay Inc.
4. Trane (The) Co.
5. Young Radiator Co.
6. Modine
7. Stering

2.01 UNIT HEATERS: (Hot Water)

A. General: Provide unit heaters in locations as indicated, and of capacities, and style and having accessories as scheduled.

B. Unit shall be complete factory assembled, wired and tested. Ready for instillation and connection to heating water piping, power and controls.

C. Materials: Horizontal delivery, heavy gauge hot water unit heater, prime coated, baked enamel finish. Extended surface condenser with aluminum fins, horizontal copper tubes, mechanically bonded to fin collars, rated for 150 PSI water pressure. Balanced aluminum fan on steel hub. Provide steel rod fan guard. Individually adjustable louvers, totally enclosed, continuous duty motor with build-in overload protection, motor mount.

D. Unit shall be factory wired to a single point terminal block.

E. Manufacturer: Subject to compliance with requirements, provide unit heaters of one of the following:

1. Airtherm Mfg. Co
2. Dunham-Bush, Inc.
3. Modine
4. Trane
5. Sterling

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF CABINET HEATERS:

A. General: Install heaters as indicated, and in accordance with manufacturer’s installation instructions.

B. Locate heater as indicated.

C. Install piping as indicated.

3.3 ELECTRICAL WIRING:

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Coordinate with the ceiling system.

3.4 ADJUSTING AND CLEANING:

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.5 COMMISSIONING:

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 238200

SECTION 238216 - HEATING AND COOLING COILS

PART I - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

B. Division 23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 SUMMARY:

A. Extent of heating and cooling coil work is indicated by drawings and schedules, and by requirements of this section.

B. Types of terminal units required for project include the following:

1. Heating coils.
2. Chilled water coils.

C. Refer to other Division 23 Sections for piping and testing, adjusting and balancing of coils, not work of this section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's specifications for coils showing dimensions, capacities, ratings, performance characteristics, gages and finishes of materials, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.

C. Operation and Maintenance Data: Submit operating and maintenance instructions and spare parts lists. Include this data, product data, shop drawings in maintenance manuals; in accordance with requirements of Section 23 01 00.

1.5 REFERENCES:

A. Codes and Standards:

1. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".

2. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".

1.6 DELIVERY, STORAGE AND HANDLING:

A. Handle coils and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged coils or components; replace with new.

B. Store coils and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.

PART II - PRODUCTS

2.1 HEATING AND COOLING COILS:

A. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410.

B. Fins: Corrugated plate sheet aluminum, maximum fins per inch as scheduled, 0.01" sheet thickness minimum.

C. Tubes: Copper tube, 5/8" diameter, 0.035" tube, 0.049" bend wall thickness, expand tube into fins.

D. Headers: Seamless Type K or L copper tube headers, vented with intermediate row and (headers fully drainable for chilled water coils provide ½" threaded connection at bottom of each header and 1/2" threaded vent connection at top of each header, see detail on drawings.) return bends, brazed connections, threaded steel pipe connections. Add ball type drain and vent valves to each header in field.

E. Casings: Construct of 16-ga continuous coated galvanized steel with fins recessed into channels to minimize air bypass.

F. Each coil section shall be furnished with a tapered frame, pitched towards the headers to facilitate draining.

G. Testing: Air tested under water to 175 psig.

H. Manufacturer: Subject to compliance with requirements, provide coils of one of the following:

1. Temtrol.
2. USA Coil

2.2 COIL DRAIN PANS:

A. Coil Drain Pans: Provide drain pans between each coil and under the entire coil bank, extend lower pan into basin. Construct all pans of 16 guage 304 or 316 stainless steel. The lower pan shall be at least 6" deep, sloped to drain, hold coil high enough to create a 6" trap off of the lower drain pan(s). Set coil into pans to catch all drips. Refer to drawings for additional detail.

PART III - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF COILS:

A. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.

B. Chilled and Heating Water Coils

1. Mount coils on steel supports to form banks or stacks as indicated, brace, secure to air intake chamber. Place in location to permit installation of bypass damper if required, provide steel baffles where required to prevent bypassing of air.

2. Pitch coil casings for drainage, not less than 1/8" toward return connections, except where drainage feature is included in coil design.

3. Each bank of cooling coils shall be supported off of floor of sufficient height to allow installation of condensate trap to allow drainage of condensate from pan when installed on suction side of fan.

4. Provide for each hot or chilled water coil unit, water supply, return connection, strainer, gate valves, automatic temperature regulating valve, balancing cocks, as indicated.

3.3 ADJUSTING AND CLEANING:

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.4 COMMISSIONING

A. The equipment and systems referenced in this section are be commissioned per Section 010800 – Commissioning General Requirements and Section 230800, Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 238216

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SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: as required per architectural requirement interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, or cable trays, penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steelpipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 019113 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260500

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths of each type of cable indicated.

C. Qualification Data: For Installer.

D. Material Certificates: For each cable and accessory type, signed by manufacturers.

E. Source quality-control test reports.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2 and NFPA 70.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect no fewer than days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cables:

a. American Insulated Wire Corp.; a Leviton Company.
b. General Cable Technologies Corporation.
c. Kerite Co. (The); Hubbell Incorporated.
d. Okonite Company (The).
e. Pirelli Cables & Systems NA.
f. Rome Cable Corporation.
g. Southwire Company.

2. Cable Splicing and Terminating Products and Accessories:

a. Engineered Products Company.
b. G&W Electric Company.
c. MPHusky.
d. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
e. RTE Components; Cooper Power Systems, Inc.
f. Scott Fetzer Co. (The); Adalet.
g. Thomas & Betts Corporation.
h. Thomas & Betts Corporation/Elastimold.
i. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: MV105.

B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682.

C. Conductor: Copper.

D. Conductor Stranding: Compact round, concentric lay, Class B).

E. Strand Filling: Conductor interstices are filled with impermeable compound.

F. Conductor Insulation: Crosslinked polyethylene.

G. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

J. Cable Jacket: Sunlight-resistant PVC.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Premolded, cold-shrink-rubber, in-line splicing kit.
4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.

B. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

C. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.7 FAULT INDICATORS

A. Indicators: Manually reset fault indicator, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables according to Division 26 Section "Common Work Results for Electrical."

E. Install direct-buried cables on leveled and tamped bed of 3-inch- thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

F. Install "buried-cable" warning tape 12 inches above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits.

I. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: Three.
3. Standoff Insulator: Three.

K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with 1-inch- wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.

L. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping."

M. Install fault indicators on each phase where indicated if not install in the new switch.

N. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

O. Identify cables according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

B. Remove and replace malfunctioning units and retest as specified above.

3.1 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:

1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THW THHN-THWN.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.4 SLEEVE SEALS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: as required by architectural documents interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: in conduitType THHN-THWN, single conductors in raceway.

G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

H. Class 1 Control Circuits: Type THHN-THWN, in raceway.

I. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

3.9 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

B. Related Sections include the following:

1. Division 2 Section "Underground Ducts and Utility Structures" for ground test wells.
2. Division 26 Section "Lightning Protection For Structures" for additional grounding and bonding materials.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Data: For the following:

1. Ground rods.
2. Chemical rods.

C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

D. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1. Comply with UL 467.

B. Comply with NFPA 70; for medium-voltage underground construction, comply with IEEE C2.

C. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Grounding Conductors, Cables, Connectors, and Rods:

a. Apache Grounding/Erico Inc.
b. Boggs, Inc.
c. Chance/Hubbell.
d. Copperweld Corp.
e. Dossert Corp.
f. Erico Inc.; Electrical Products Group.
g. Framatome Connectors/Burndy Electrical.
h. Galvan Industries, Inc.
i. Harger Lightning Protection, Inc.
j. Hastings Fiber Glass Products, Inc.
k. Heary Brothers Lightning Protection Co.
l. Ideal Industries, Inc.
m. ILSCO.
n. Kearney/Cooper Power Systems.
o. Korns: C. C. Korns Co.; Division of Robroy Industries.
p. Lightning Master Corp.
q. Lyncole XIT Grounding.
r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
s. Raco, Inc.; Division of Hubbell.
t. Robbins Lightning, Inc.
u. Salisbury: W. H. Salisbury & Co.
v. Superior Grounding Systems, Inc.
w. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Material, copper-clad and copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded copper cable.

F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.
2. Assembly of Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

H. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit forms, and selected per manufacturers written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad.

1. Size: 3/4 inches in diameter, 120 inches long.

B. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a minimum 4/0 bare conductor or as shown. Provide backfill material recommended by manufacturer.

C. Test Wells: Provide handholes as specified in Division 2 Section "Underground Ducts and Utility Structures."

PART 3 - EXECUTION

3.1 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

F. Grounding Bus: Install in all electrical and all telephone equipment rooms, in rooms housing service equipment, under all raised floors and elsewhere as indicated.

1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
2. At doors, route the bus up to the top of the doorframe, across the top of the doorway, and down to the specified height above the floor.

G. Underground Grounding Conductors: Use tinned- copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment-grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.

D. Computer Outlet Circuits: Install insulated equipment-grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment-grounding conductor connected to the receptacle-grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment-grounding conductor. Isolate equipment-grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Nonmetallic Raceways: Install an equipment-grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

H. Air-Duct Equipment Circuits: Install an equipment-grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

I. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment-grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

J. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

K. Metal Poles Supporting Outdoors Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment-grounding conductor with supply branch-circuit conductors.

L. Common Ground Bonding with Lightning Protection System: Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

3.3 COUNTERPOISE

A. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 2/0 AWG for counterpoise and for tap to building steel. Bury counterpoise not less than 18 inches below grade and 24 inches from building foundation.

3.4 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

G. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

H. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade or floor.

I. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, Paragraph 250-81(c), using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

3.5 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.6 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Duct Banks: Install a grounding conductor with at least 50 percent ampacity of the largest phase conductor in the duct bank.

B. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is

placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.7 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

    a. Equipment Rated 500 kVA and Less: 10 ohms.
    b. Equipment Rated 500 to 1000 kVA: 5 ohms.
    c. Equipment Rated More Than 1000 kVA: 3 ohms.
    d. Substations and Pad-Mounted Switching Equipment: 5 ohms.
    e. Manhole Grounds: 10 ohms.

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260526

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:

1. Division 2 Section "Underground Ducts and Utility Structures" for exterior ductbanks, manholes, and underground utility construction.
2. Division 7 Section "Through-Penetration Firestop Systems" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
3. Division 26 Section "Common Work Results For Electrical" for supports, anchors, and identification products.
4. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for seismic restraints and bracing of raceways, boxes, enclosures, and cabinets.
5. Division 26 Section "Wiring Devices" for devices installed in boxes and for floor-box service fittings.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: Show fabrication and installation details of components for raceways, fittings, boxes, enclosures, and cabinets.

C. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting seismic restraints.
2. Detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Manufacturer Seismic Qualification Certification: Submit certification that enclosures, cabinets, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 METAL CONDUIT AND TUBING

A. Manufacturers:

   1. AFC Cable Systems, Inc.
   2. Alflex Inc.
   3. Anamet Electrical, Inc.; Anaconda Metal Hose.
   4. Electri-Flex Co.
   5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
   6. LTV Steel Tubular Products Company.
   7. Manhattan/CDT/Cole-Flex.
   8. O-Z Gedney; Unit of General Signal.
   9. Wheatland Tube Co.

B. Minimum Size ¾” for indoor, 1” for outdoor.

C. Rigid Steel Conduit: ANSI C80.1.

D. IMC: ANSI C80.6.

E. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.

F. Plastic-Coated IMC and Fittings: NEMA RN 1.

G. EMT and Fittings: ANSI C80.3.

   1. Fittings: Set-screw type.

H. FMC: Zinc-coated steel.

I. LFMC: Flexible steel conduit with PVC jacket.

J. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers:

   1. American International.
   2. Anamet Electrical, Inc.; Anaconda Metal Hose.

3. Arnco Corp.
4. Cantex Inc.
5. Certainteed Corp.; Pipe & Plastics Group.
6. Condux International.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; Division of Hubbell, Inc.
12. Spiralduct, Inc./AFC Cable Systems, Inc.
13. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Schedule 40 PVC.

D. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.

E. LFNC: UL 1660.

F. Minimum Size ¾" for indoor, 1" for outdoor.

2.4 METAL WIREWAYS

A. Manufacturers:

1. Hoffman.
2. Square D.
3. Walker.

B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

E. Wireway Covers: Screw-cover type .

F. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

A. Manufacturers:

1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.
3. Hubbell

4. Wiremold

B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

2.6 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating .

1. Manufacturers:

a. Airey-Thompson Sentinel Lighting; Wiremold Company (The).
b. Thomas & Betts Corporation.
c. Walker Systems, Inc.; Wiremold Company (The).
d. Wiremold Company (The); Electrical Sales Division.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color.

1. Manufacturers:

a. Butler Manufacturing Co.; Walker Division.
b. Enduro Composite Systems.
c. Hubbell, Inc.; Wiring Device Division.
d. Lamson & Sessions; Carlon Electrical Products.
e. Panduit Corp.
f. Walker Systems, Inc.; Wiremold Company (The).
g. Wiremold Company (The); Electrical Sales Division.

C. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.7 DUCT BANKS

A. Duct banks will be provided to house high voltage or communication underground cables. Duct banks will be concrete encased round bore plastic duct. The duct sizes are called on the drawing sheet. Duct banks shall have a minimum slope of 4 inches per 100 ft. Seal around all cables entering man hole with permagum. Provide plastic plugs in both ends of all unused ducts and seal with silicon sealant. Add die to the concrete for electrical systems.

B. Concrete encasement will be a minimum of three inches between ducts and between ducts and earth. The top of the concrete encasement will be a minimum of 3 ft. below finished grade. Care shall be taken during installation to insure no debris gets in to the line. After completion a mandrel not less than 12 inches long and approximately 1-1/2 inches diameter less than the duct diameter will be pulled through each duct to insure that no debris has collected in the duct. Engineer should inspect duct bank construction before concrete is poured. Provide polypropylene pull rope in each unused duct.

C. Where duct banks enter manholes, buildings or vaults, a 10 ft. length of rigid galvanized steel conduit will be used for each duct. All conduit bends over 30 degrees shall be made of rigid galvanized steel.

2.8 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. Emerson/General Signal; Appleton Electric Company.
3. Erickson Electrical Equipment Co.
4. Hoffman.
5. Hubbell, Inc.; Killark Electric Manufacturing Co.
6. O-Z/Gedney; Unit of General Signal.
7. RACO; Division of Hubbell, Inc.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet-PLM Division.
10. Spring City Electrical Manufacturing Co.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Floor Boxes: Cast metal, fully adjustable, rectangular.

F. Floor Boxes: Nonmetallic, nonadjustable, round.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

J. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

2.9 FACTORY FINISHES

A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.

B. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: Rigid steel or IMC.
2. Concealed: Rigid steel or IMC.
3. Underground, Single Run: RNC.
4. Underground, Grouped: RNC.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R.

B. Indoors:

1. Exposed: EMT .
2. Concealed: EMT.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Damp or Wet Locations: Rigid steel conduit.
5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:

a. Damp or Wet Locations: NEMA 250, Type 4,stainless steel.

C. Minimum Raceway Size: 3/4-inch trade size for indoor, 1-inch trade size for outdoor.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz.

F. Do not install aluminum conduits for this project.

3.2 INSTALLATION

A. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

B. Complete raceway installation before starting conductor installation.

C. Support raceways as specified in Division 26 Section "Common Work Results For Electrical."

D. Install temporary closures to prevent foreign matter from entering raceways.

E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.

F. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

H. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches of concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
4. Change from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above the floor.

I. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.

1. Run parallel or banked raceways together on common supports.
2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

J. Join raceways with fittings designed and approved for that purpose and make joints tight.

1. Use insulating bushings to protect conductors.

K. Tighten set screws of threadless fittings with suitable tools.

L. Terminations:

1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

M. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

N. Telephone and Signal System Raceways, 2-Inch Trade Size and Smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

O. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

P. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; LFMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

Q. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.

R. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

S. Set floor boxes level and flush with finished floor surface.

T. Set floor boxes level. Trim after installation to fit flush with finished floor surface.

U. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.3 ACCESS DOORS

A. Related documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Summary: Extent, location, and size of each type of access door required are indicated on drawings.

C. Submittals:

1. Product Data: Submit manufacturers technical data and installation instructions for each type of access door assembly, including setting drawings, templates, instructions and directions for installation of anchorage devices.
2. Include complete schedule, including types, general locations, sizes, wall and ceiling construction details, finishes, latching or locking provisions, and other data pertinent to installation.

D. Quality assurance:

1. Size variations: Obtain Architect’s acceptance of manufacturer’s standard size units which may vary slightly from sizes indicated.

E. Coordination: Furnish inserts and anchoring devices which must be built into other work for installation of access doors. Coordinate delivery with other work to avoid delay.

F. Manufacturers: Subject to compliance with requirements, provide access doors by one of the following:
1. Bilco Company (or approved equal)

G. Materials and fabrication: Furnish each access door assembly manufactured as integral unit, complete with all parts and ready for installation.

1. Locking Devices: Furnish flush, screwdriver-operated cam locks number required to hold door in flush smooth plane when closed.
2. Provide one cylinder lock per access door. Furnish 2 keys per lock. Key all locks alike, unless otherwise scheduled.

H. Installation: Comply with manufacturer’s instructions for installation of access doors.

1. Coordinate installation with work of other trades.

I. Adjust and Clean:

1. Adjust hardware and panels after installation for proper operation.
2. Remove and replace panels or frames which are warped, bowed or otherwise damaged.

3.4 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.5 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

3.6 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260533

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes aluminum cable trays and accessories.

B. Related Sections include the following:

1. Division 7 Section "Through-Penetration Firestop Systems" for firestopping materials and installation at penetrations through walls, ceilings, and other fire-rated elements.
2. Division 26 Section "Common Work Results For Electrical" for cable tray supports not specified in this Section.
3. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for mounting and anchoring cable trays.

1.3 SUBMITTALS

A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting seismic restraints.
    b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

C. Coordination Drawings: Floor plans and sections drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural and mechanical elements. Show the following:

1. Vertical and horizontal offsets and transitions.

2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above floor or bottom of ceiling structure.

D. Product Certificates: For each type of cable tray, signed by product manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that cable trays, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Cable Tray Units: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For testing agency.

G. Field Test Reports: Written reports specified in Part 3.

H. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA VE 1, "Metal Cable Tray Systems," if cable tray types specified are defined in the standard.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate layout and installation of cable trays and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-Line Systems, Inc.
2. Mono-Systems, Inc.
3. MPHusky.
4. P-W Industries, Inc.
5. Thomas & Betts Corporation.

2.2 MATERIALS AND FINISHES

A. Cable Trays, Fittings, and Accessories: Steel, with the following finish:

1. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 coating.
2. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2.
3. PVC coating applied in a fluidized bed or by electrostatic spray.
4. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment.

B. Cable Trays, Fittings, and Accessories: Aluminum, complying with Aluminum Association's alloy 6063-T6 for rails, rungs, and cable trays, and alloy 5052-H32 or alloy 6061-T6 for fabricated parts.

C. Cable Trays, Fittings, and Accessories: Cadmium plated.

D. Protect steel hardware against corrosion by galvanizing according to ASTM B 633 or cadmium plating according to ASTM B 766.

E. Fabricate cable tray products with rounded edges and smooth surfaces.

F. Sizes and Configurations: 24” Wide, 4” Loading Depth, 5” Side rail, 8” Rung Spacing, Ladder type. 8ft maximum span is required. Brace every 8 ft. Loading shall be less than 297 lb/ft.

2.3 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 26 Section "Common Work Results For Electrical."

2.5 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CABLE TRAY INSTALLATION

A. Remove burrs and sharp edges from cable trays.

B. Fasten cable tray supports securely to building structure as specified in Division 26 Section "Common Work Results For Electrical," unless otherwise indicated.

1. Locate and install supports according to NEMA VE 1.

C. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independently of fittings. Do not carry weight of cable tray on equipment enclosure.

D. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed 90 feet. Space connectors and set gaps according to NEMA VE 1.

E. Make changes in direction and elevation using standard fittings.

F. Make cable tray connections using standard fittings.

G. Locate cable tray above piping unless accessibility to cable tray is required or unless otherwise indicated.

H. Seal penetrations through fire and smoke barriers according to Division 7 Section "Through-Penetration Firestop Systems."

I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

J. Workspace: Install cable trays with sufficient space to permit access for installing cables.

K. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

L. Install covers after installation of cable is completed.

M. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.3 CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

C. Testing: Perform the following field quality-control testing:

1. After installing cable trays and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform the following electrical test and visual and mechanical inspections:

    a. Visually inspect each cable tray joint and each ground connection for mechanical continuity.
    b. Measure ground resistance of each system of cable tray from the most remote element to the point where connection is made to service disconnect enclosure grounding terminal. Record resistance in ohms.

3. Report results in writing.

3.5 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure cable tray is without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

3.6 CABLE TRAY SCHEDULE

A. Run Designation:

1. Type: Ladder .
2. Material and Finish: Aluminum.
3. Width: As shown on the plans or 24” minimum
4. Cross-Rung Spacing: 8”
5. Minimum Fitting Radius: 24”
6. Inside Depth: 4”
7. Cover Type: None.
8. NEMA Load/Span Class: 297 lb.

3.7 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260536

SECTION 260548 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

1.3 DEFINITIONS

A. BOCA: BOCA National Building Code.

B. SBC: Standard Building Code.

C. UBC: Uniform Building Code.

D. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

E. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

1.4 SUBMITTALS

A. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.

1. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by an agency approved by authorities having jurisdiction.

B. Shop Drawings: For anchorage and bracing not defined by details and charts on Drawings. Indicate materials, and show designs and calculations signed and sealed by a professional engineer.

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

2. Details: Detail fabrication and arrangement. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods, and spacings, identifying components and listing their strengths. Indicate direction and value of forces transmitted to the structure during seismic events.

3. Preapproval and Evaluation Documentation: By an agency approved by authorities having jurisdiction, showing maximum ratings of restraints and the basis for approval (tests or calculations).

C. Coordination Drawings: Plans and sections drawn to scale and coordinating seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity.

D. Product Certificates: Signed by manufacturers of seismic restraints certifying that products furnished comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Material Test Reports: From a qualified testing agency indicating and interpreting test results of seismic control devices for compliance with requirements indicated.

1.5 QUALITY ASSURANCE

A. Comply with seismic restraint requirements in UBC, unless requirements in this Section are more stringent.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing seismic engineering services, including the design of seismic restraints, that are similar to those indicated for this Project.

1.6 PROJECT CONDITIONS

A. Project Seismic Zone and Zone Factor as Defined in UBC: Zone 3, Zone Factor 0.30.

1.7 PROJECT CONDITIONS

A. Project Seismic Hazard Exposure Group as Defined in BOCA or SBC.

1.8 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. Erico, Inc.
4. GS Metals Corp.
5. Loos & Company, Inc.
6. Mason Industries, Inc,
7. Powerstrut.
8. Thomas & Betts Corp.
9. Unistrut Corporation.

2.2 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.4 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch- thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 570, GR 33.
2. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 APPLICATION

A. Generator Sets: Comply with Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

3.2 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

3.3 STRUCTURAL ATTACHMENTS

A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.

B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.

C. Attachments to Existing Concrete: Use expansion anchors.

D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.

E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.

F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

G. Attachments to Wood Structural Members: Install bolts through members.

H. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

3.4 ELECTRICAL EQUIPMENT ANCHORAGE

A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.

B. Anchor panelboards, motor-control centers, motor controls, switchboards, switchgear, transformers, fused power-circuit devices, transfer switches, busways, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:

1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

3.5 SEISMIC BRACING INSTALLATION

A. Install bracing according to spacings and strengths indicated by approved analysis.

B. Expansion and Contraction: Install to allow for thermal movement of braced components.

C. Cable Braces: Install with maximum cable slack recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

3.7 FIELD QUALITY CONTROL

A. Testing: Test pull-out resistance of seismic anchorage devices.

1. Provide necessary test equipment required for reliable testing.
2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven working days' advance notice.
4. Obtain Architect's approval before transmitting test loads to the structure. Provide temporary load-spreading members.
5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.
8. Record test results.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260548

SECTION 260553 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

1. Color: Black letters on orange field.
2. Legend: Indicates voltage and service.

B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.

C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

D. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

E. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend indicating type of underground line.

F. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

G. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch- thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

I. Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.

J. Brass or Aluminum Tags: 2 by 2 by 0.05-inch metal tags with stamped legend, punched for fastener.

K. Concrete-Incase: Die concrete for each system differently.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 lb minimum.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

C. Colored Concrete: Use for all concrete encased systems, differentiate between Medium Voltage and other systems.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:

1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to conduits concealed within wall.
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.

4. Entire surface of exposed conduits.

F. Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

G. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

1. Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
3. Apply the following colors to the systems listed below:

a. Fire-Suppression Supervisory and Control System: Red and yellow.
b. Combined Fire-Alarm and Security System: Red and blue.
c. Security System: Purple
d. Mechanical and Electrical Supervisory System: Green and blue.
e. Telecommunications System: Blue
f. Fire-Alarm System: Red.
g. Emergency power system: Yellow.
h. 277/480 volts system: Brown.
i. 120/208 volts system: Black.
j. Clocks & Bells: Orange.
k. Sound System: Green.

Comment: SELECT TYPES OF LABELS AND TAGS IN PARA BELOW TO SUIT PROJECT.

H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

I. Circuit Identification Labels on Boxes: Install labels externally.

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card-stock tags.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

J. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

K. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:

1. 208/120-V Conductors:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral : White
   e. Ground : Green

2. 480/277-V Conductors:

   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral : Gray
   e. Ground : Green

3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

   a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
   b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

L. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.

1. Legend: 1/4-inch- steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Tag Fasteners: Nylon cable ties.
3. Band Fasteners: Integral ears.

M. Apply identification to conductors as follows:

1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

N. Apply warning, caution, and instruction signs as follows:

1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

O. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- high lettering on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

1. Panelboards, electrical cabinets, and enclosures.
2. Access doors and panels for concealed electrical items.
3. Electrical switchgear and switchboards.
4. Electrical substations.
5. Emergency system boxes and enclosures.
6. Motor-control centers.
7. Disconnect switches.
8. Enclosed circuit breakers.
9. Motor starters.
10. Push-button stations.
11. Power transfer equipment.
12. Contactors.
13. Remote-controlled switches.
14. Dimmers.
15. Control devices.
16. Transformers.
17. Power-generating units.
18. Clock/program master equipment.
19. TV/audio-monitoring master station.
20. Fire alarm master station or control panel.
21. Security-monitoring master station or control panel.
22. Uninterruptible power supplies.
23. Power distribution units.

3.2 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260553

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices.

1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals:

1. Coordination-study input data, including completed computer program input data sheets.
2. Coordination-study report.
3. Equipment evaluation report.
4. Setting report.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

C. Testing Agency Qualifications: Member company of the InterNational Electrical Testing Association.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise testing specified in Part 3.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

B. Computer Software Developers: Subject to compliance with requirements, provide computer software programs developed by one of the following:

1. CYME International, Inc.
2. EDSA Micro Corporation.
3. Electrical Systems Analysis, Inc.
4. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.2 FAULT-CURRENT STUDY

A. Source Impedance: As an infinite bus on primary side of utility transformer.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
2. Circuit Breakers: IEEE C37.13.

E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.3 COORDINATION STUDY

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical distribution system diagram showing the following:

    a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
    b. Circuit-breaker and fuse-current ratings and types.

c. Relays and associated power and current transformer ratings and ratios.
d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
e. Generator kilovolt amperes, size, voltage, and source impedance.
f. Cables. Indicate conduit material, sizes of conductors, conductor insulation, and length.
g. Busway ampacity and impedance.
h. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Magnetic inrush current overload capabilities of transformers.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Ratings, types, and settings of utility company's overcurrent protective devices.
e. Special overcurrent protective device settings or types stipulated by utility company.
f. Time-current-characteristic curves of devices indicated to be coordinated.
g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

B. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

C. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

D. Comply with IEEE 242 recommendations for fault currents and time intervals.

E. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

F. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

G. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

H. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:

   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.

3. Completed data sheets for setting of overcurrent protective devices.

3.4 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to set overcurrent protective devices within equipment.

B. Testing: Owner will engage a qualified testing agency to perform device setting.

C. Testing: Engage a qualified testing agency to perform the following device setting and to prepare test reports.

D. Testing: Perform the following device setting and prepare reports:

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

   a. Verify that overcurrent protective devices meet parameters used in studies.

b. Adjust devices to values listed in study results.

2. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260573

SECTION 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

0108 00 Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

260500 Common Work Results for Electrical
260513 Medium- Voltage Cables
260519 Low- Voltage Electrical Power Conductors and Cables
260526 Grounding and Bonding for Electrical Systems
260533 Raceways and Boxes for Electrical Systems
260536 Cable Trays for Electrical Systems
260548 Vibration and Seismic Controls for Electrical Systems
260553 Identification
260573 Overcurrent Protective Device Coordination Study
260923 Lighting Control Devices
261200 Medium- Voltage Transformers
261300 Medium- Voltage Switchgear
262200 Low- Voltage Transformers
262413 Switchboards
262416 Panelboards
262419 Motor- Control Centers
262726 Wiring Devices
262813 Fuses
262816 Enclosed Switches and Circuit Breakers
262923 Variable Frequency Motor controllers
263213 Engine Generators
263353 Static Uninterruptible Power Supply
263600 Transfer Switches
261113 Lighting Protection for Structures
264313 Transient Voltage Suppression for Low Voltage Electrical Power Circuits
265100 Interior Lighting
265600 Exterior Lighting

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 010800, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 010800, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

A	B	C	D	E	F	G
System Description / Documents Required	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Medium-Voltage Cables-260513						
NETA ATS inspection and test per 3.2 A.						
Systems Readiness Checklist		CA Provided				
Low-Voltage Electrical Power conductors and cables-260519						
Torque values per 3.4 A.						
NETA ATS inspection and test per 3.8 B. 2.						
Infrared scanning per 3.8 B. 3.						
Systems Readiness Checklist		CA Provided				
Ground and Bonding for electrical systems-260526						
Torque values per 3.5						
Field quality control testing per 3.7						
Systems Readiness Checklist		CA Provided				
Cable trays for electrical systems-260536						
Torque values per 3.3 B.						
Field quality control testing per 3.4						
Systems Readiness Checklist		CA Provided				
Vibration and seismic controls for electrical systems-260548						
Field quality control testing per 3.7						
Systems Readiness Checklist		CA Provided				

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A System Description / Documents Required	B Responsible Contractor	C Proposed Document Received	D OK	E Completed Document Received	F OK	G Notes
Overcurrent Protection Device Coordination Study - 260573						
Fault current study per 3.2						
Coordination study per 3.3						
Overcurrent protective device setting/testing per 3.4						
Systems Readiness Checklist		CA Provided				
Lighting Control Devices – 260923						
Torque values per 3.4 C.						
Photoelectric setting verification per 3.4 D.						
Electrical tests per 3.4 E.						
Systems Readiness Checklist		CA Provided				
Medium-Voltage Transformers 261200						
Torque values per 3.4 C.						
Test per NETA ATS 7.2 (per 3.5 B.)						
Test/adjust safeties per 3.5 B.						
7-day voltage logging per 3.6 A. 1.						
Infrared scanning per 3.6 B.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Medium-voltage Switchgear 261300						
Production test data per 5.5						
Factory test data per 5.6						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Low-Voltage Transformers 262200						

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A System Description / Documents Required	B Responsible Contractor	C Proposed Document Received	D OK	E Completed Document Received	F OK	G Notes
Torque Values per 3.3 C.						
48-hour secondary voltage logging per 3.4 A.						
Output voltage and tap settings per 3.4 C.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Switchboards 262413						
Torque Values per 3.5 B.						
Insulation resistance tests per 3.6 A.1						
Continuity tests per 3.6 A.2						
Testing per NETA ATS (3.6 B.)						
Infrared scanning per 3.6 C.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Panelboards – 262416						
Torque Values per 3.3 B.						
Insulation resistance tests per 3.4 A.1						
Continuity tests per 3.4 A.2						
Testing per NETA ATS (3.4 B.)						
Phase Load Balance per 3.4 C.						
Infrared scanning per 3.4 D.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Motor-Control Centers 262419						
Torque Values per 3.6 C.						
Insulation resistance tests per 3.7 A.1						
Continuity tests per 3.7 A.2						
Testing per NETA ATS (3.7 B.)						

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A System Description / Documents Required	B Responsible Contractor	C Proposed Document Received	D OK	E Completed Document Received	F OK	G Notes
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Wire Devices 262726						
Torque Values per 3.3 C.						
Polarity, continuity & grounding verification per 3.4 A. 1.						
GFCI Operation per 3.4 A. 2.						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				
Enclosed Switches and Circuit Breakers 262816						
Torque Values per 3.4 C.						
Insulation resistance tests per 3.5 A.1						
Continuity tests per 3.5 A.2						
Testing per NETA ATS (3.5 B.)						
Infrared scanning per 3.5 C.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Variable Frequency Motor Controllers 262923						
Field testing per 3.5						
Harmonic distortion tests per 3.6						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Engine Generators						
Fuel Test per 3.6 C. 2.						
Test per NETA ATS (3.6 C.3.)						

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A System Description / Documents Required	B Responsible Contractor	C Proposed Document Received	D OK	E Completed Document Received	F OK	G Notes
NFPA 110 full-load pickup test per 3.6 C. 4.						
Battery tests per 3.6 C. 5.						
Battery charger tests per 3.6 C. 6.						
Exhaust back-pressure test per 3.6 C. 8.						
Exhaust emission test per 3.6 C. 9.						
Voltage and frequency transient stability test per 3.6 C. 10.						
Harmonic content tests per 3.6 C. 11.						
Load test per 3.6 C. 12						
Fuel test per 3.6 H.						
Battery equalization per 3.7						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Static Uninterruptible Power Supply 263353						
Battery equalization per 3.4						
Protective and alarm function tests per 3.5 B. 2.						
Remote monitoring tests per 3.5 B. 3.						
Load testing per 3.5 C. 2.						
Seismic testing per 3.5 D.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Transfer Switches 263600						
Field QC electrical tests per 3.5 B. 1.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Lighting Protection for Structures						
LPI inspector’s reports per 3.3 A.		n/a				

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A System Description / Documents Required	B Responsible Contractor	C Proposed Document Received	D OK	E Completed Document Received	F OK	G Notes
UL inspection report per 3.3 B.		n/a				
ETL inspection report per 3.3 C.		n/a				
Systems Readiness Checklist		CA Provided				
Transient Voltage Suppression for Low-Voltage Electrical Power Circuits – 264313						
Torque values per 3.2						
Field QC testing per NETA ATS (per 3.3)						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Interior Lighting – 265100						
Torque values per 3.2						
Operation verification per 3.3 B.						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				
Exterior Lighting – 265600						
Torque values per 3.2						
Operation verification per 3.3						
Manufacturer Start-up Documentation						
Systems Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.
B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.
C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.
D. Indicates that CA has received and approved proposed installation and start-up documentation.
E. Date the completed documents are received by the CA from the responsible Contractor.
F. Indicates that CA has received and approved completed documentation.
G. Notes on status of forms, irregularities and rework needed.

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Medium Voltage Cables
System Readiness Checklist (Preliminary Version)

Installation:

- Conduits cleaned prior to pulling cables.
- Cables labeled per the project requirements.
- Exposed cable ends inspected for damaged and damage corrected as required.
- All cable shields, cable terminations, metallic conduits, pad mounted transformers, fence around transformers are grounded per the project requirements.
- All grounding and bonding procedures completed per the project requirements.

Start-Up:

- Commissioning Authority notified for witness of start-up.
- Continuity testing complete.
- Torque tests complete.
- Grounding testing complete.
- Voltage verification tests complete.
- Insulation tests complete.
- NETA ATS testing complete
- Manufacturer start-up has been performed.
- All above listed test reports are attached.

Readiness:

- Manufacturer's installation and start-up procedures were followed.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment and systems are labeled per project documents.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Low Voltage Cables
System Readiness Checklist (Preliminary Version)

Installation:

- Conduits cleaned prior to pulling cables.
- Cables labeled per the project requirements.
- Exposed cable ends inspected for damaged and damage corrected as required.
- All cable shields, cable terminations, metallic conduits, pad mounted transformers, fence around transformers are grounded per the project requirements.
- All grounding and bonding procedures completed per the project requirements.

Start-Up:

- Commissioning Authority notified for witness of start-up.
- Continuity testing complete.
- Torque tests complete.
- Grounding testing complete.
- Voltage verification tests complete.
- Insulation tests complete.
- NETA ATS testing complete
- Infrared testing complete.
- Manufacturer start-up has been performed.
- All above listed test reports are attached.

Readiness:

- Manufacturer's installation and start-up procedures were followed.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment and systems are labeled per project documents.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Grounding and Bonding for Electrical Systems
System Readiness Checklist (Preliminary Version)

Installation:

All grounding and bonding systems are completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Torque tests complete.

Field QC ground testing complete

Ground location drawings completed

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Cable Trays for Electrical Systems
System Readiness Checklist (Preliminary Version)

Installation:

All cable tray systems are completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Torque tests complete.

Field QC testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Vibration and seismic controls for Electrical Systems
System Readiness Checklist (Preliminary Version)

Installation:

All seismic control systems are completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Field QC testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Overcurrent Protection Device Coordination Study
System Readiness Checklist (Preliminary Version)

Installation:
n/a

Start-Up:

Commissioning Authority notified for witness of start-up.

Fault current study complete

Coordination study complete

Overcurrent protective device setting/testing complete

All above listed test reports are attached.

Readiness:

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Lighting Control Devices
System Readiness Checklist (Preliminary Version)

Installation:

All seismic control systems are completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete

Photo electric settings verified

Electrical testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Medium Voltage Transformers
System Readiness Checklist (Preliminary Version)

Installation:

Transformers mounted/secured per the project requirements. Floor mounted transformers provided with resilient vibration isolation pads.

All terminals, connectors screws and bolts tightened per the manufacturers requirements.

All internal resilient mounts have been verified as free floating.

Flexible conduit used where conduit is connected to transformer enclosure.

All cable shields, cable terminations, metallic conduits, pad mounted transformers, fence around transformers are grounded per the project requirements.

All grounding and bonding procedures completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Test per NETA ATS 7.2 complete

Test/adjust safeties complete

7-day voltage logging complete

Infrared scanning complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Medium Voltage Switchgear
System Readiness Checklist (Preliminary Version)

Installation:

Switchgear mounted/secured per the project and manufacturer requirements

Fuses installed as required.

Conductors supported using nylon ties/warps in accordance with manufacturer recommendations.

Prior to energizing all components checked operability, settings and interlocks.

Start-Up:

Commissioning Authority notified for witness of start-up.

Production test reports complete.

Factory test reports complete.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Insulation resistance testing complete.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Low Voltage Transformers
System Readiness Checklist (Preliminary Version)

Installation:

Transformers mounted/secured per the project requirements. Floor mounted transformers provided with resilient vibration isolation pads.

All terminals, connectors screws and bolts tightened per the manufacturers requirements.

All internal resilient mounts have been verified as free floating.

Flexible conduit used where conduit is connected to transformer enclosure.

All cable shields, cable terminations, metallic conduits, pad mounted transformers, fence around transformers are grounded per the project requirements.

All grounding and bonding procedures completed per the project requirements.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

48-hour secondary voltage logging complete.

Output voltage and tap settings recorded.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Switchboards
System Readiness Checklist (Preliminary Version)

Installation:

Switchboards mounted/secured per the project and manufacturer requirements

Fuses installed as required.

Conductors supported using nylon ties/warps in accordance with manufacturer recommendations.

Prior to energizing all components checked operability, settings and interlocks.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Insulation resistance testing complete.

NETA ATS testing complete

Infrared testing complete.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Panelboards
System Readiness Checklist (Preliminary Version)

Installation:

- Panelboards mounted/secured per the project and manufacturer requirements
- All terminals, connectors screws and bolts tightened per the manufacturers requirements.
- Spare conduits and space for future loads have been provided.
- Conductors arranged neatly and supported using nylon ties/warps in accordance with manufacturer recommendations.
- Circuit schedule updated, typed and in panelboards.
- All grounding and bonding procedures completed per the project requirements.

Start-Up:

- Commissioning Authority notified for witness of start-up.
- Continuity testing complete.
- Torque tests complete.
- Grounding testing complete.
- Voltage verification tests complete.
- Insulation tests complete.
- NETA ATS testing complete
- Phase load balance testing complete
- Infrared testing complete.
- Manufacturer start-up has been performed.
- All above listed test reports are attached.

Readiness:

- Manufacturer's installation and start-up procedures were followed.
- Damaged factory finishes have been replaced, repaired or touched up.
- Equipment and systems are labeled per project documents.
- Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Motor Control Centers
System Readiness Checklist (Preliminary Version)

Installation:

Motor controllers and motor control centers mounted/secured per the project and manufacturer requirements.

Controller pilot lights have been checked and are functional.

Control power transformers are grounded per the project requirements.

Branch circuits verified for proper sizing with equipment nameplate data.

Motor overload protection has been sized and installed as required for controlled equipment.

Conductors arranged neatly and supported using nylon ties/warps in accordance with manufacturer recommendations.

Motor data has provided inside of each cubicle door in motor control centers per the project requirements

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Insulation tests complete.

NETA ATS testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Wire Devices
System Readiness Checklist (Preliminary Version)

Installation:

Wiring devices installed per project documents

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Polarity testing complete.

GFCI Testing complete.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Enclosed Switches and Circuit Breakers
System Readiness Checklist (Preliminary Version)

Installation:

Switchgear mounted/secured per the project and manufacturer requirements

Fuses installed as required.

Conductors supported using nylon ties/warps in accordance with manufacturer recommendations.

Prior to energizing all components checked operability, settings and interlocks.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Insulation resistance testing complete.

Testing per NETA ATS complete.

Infrared scanning complete.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Variable Frequency Motor Controllers
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

Equipment and systems are labeled per project documents.

Disconnect within sight of unit and labeled, power active, overload protection appropriate

External controls installed.

Controlled parameter sensor (air or water) installed and configured through control system.

Proper ventilation has been provided to over temperature nuisance trips.

Cooling fan filters installed and clean.

Start-Up:

Commissioning Authority notified for witness of start-up.

Voltage, grounding, insulation resistance and overload protection verified

Motor operation and rotation verified.

Operating limits and alarm set

High temperature alarm

High amperage alarm

Minimum frequency

Ramp rates

By-pass frequencies

_____

Internal controls and safeties verified operational.

External controls verified operational.

Operating parameters measured and recorded.

Field tests and Harmonic distortion tests

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer’s installation and start-up procedures were followed. Attach completed checklists.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

Area and equipment have been cleaned, construction debris removed.

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Engine Generators
System Readiness Checklist (Preliminary Version)

Installation:

- Manufacturer's required maintenance clearance provided.
- Generator has been provided with vibration isolators and anchored as required to concrete pad.
- Fuel cylinder, piping, valves, regulator, flex connection, dry filter installed and leak tested.
- System fluids and lubrication have been checked.
- Battery charger and heater installed and operational.
- Engine heater installed and operational.
- Engine controls and instrumentation per project documents
- Engine glycol level verified.
- Automatic transfer switch and associated wiring has been installed per the manufacturers recommendations.
- Controls and remote annunciator installed and verified operational.
- Generator remote monitoring connection has been provided.
- All control wiring installed and complete.

Start-Up:

- Commissioning Authority has been notified for witness of start-up.
- Torque tests complete.
- Grounding testing complete.
- Initial fuel test completed
- Test per NETA ATS completed
- NFPA 110 full-load pickup test completed
- Battery tests completed
- Battery charger tests completed
- Exhaust back-pressure test completed
- Exhaust emission test completed
- Voltage and frequency transient stability test completed
- Harmonic content tests completed
- Load test completed
- Final fuel test completed.
- Battery equalization verification completed.
- All pilot lights have been checked and are functional.
- Internal controls and safeties verified operational.
- External controls verified operational.
- Manufacturer start-up has been performed, transfer switch operation verified, time delays verified.
- Automatic transfer switch has been configured and time delays programmed per the project requirements.
- All above listed test reports are attached.

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System Readiness Checklist (Preliminary Version)
Engine Generators (continued)

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Static Uninterruptible Power Supply
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

All control wiring installed and complete.

Start-Up:

Commissioning Authority has been notified for witness of start-up.

Torque tests complete.

Grounding testing complete.

Battery equalization verification complete

Protective and alarm function tests complete.

Remote monitoring tests complete.

Load testing complete.

Seismic testing complete.

Internal controls and safeties verified operational.

External controls verified operational.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer’s installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Transfer Switches
System Readiness Checklist (Preliminary Version)

Installation:

Manufacturer's required maintenance clearance provided.

All control wiring installed and complete.

Start-Up:

Commissioning Authority has been notified for witness of start-up.

Torque tests complete.

Grounding testing complete.

Internal controls and safeties verified operational.

External controls verified operational.

Field QC tests complete

Manufacturer start-up has been performed.

Automatic transfer switch has been configured and time delays programmed per the project requirements.

All above listed test reports are attached.

Readiness:

Manufacturer’s installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Lighting Protection for Structures
System Readiness Checklist (Preliminary Version)

Installation:

All lighting control systems are completed per the project requirements.

Start-Up:

LPI inspector's report complete.

UL inspection report complete.

ETL inspection report complete.

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Transient Voltage Suppression
System Readiness Checklist (Preliminary Version)

Installation:

Units installed per project documents.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

NETA ATS testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the Test Engineer and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Interior Lighting Systems
System Readiness Checklist (Preliminary Version)

Installation:

All relays have been labeled per the project requirements.

All low voltage wiring has been installed in conduit per the project requirements.

Luminaries have been installed, aimed and adjusted as required.

All luminaries have cleaned and surfaces touched-up as required.

All control wiring installed and complete.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Lighting circuits have been verified.

Multi-level lighting has been verified.

Operational testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

As-built drawings have been updated and submitted.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Exterior Lighting Systems
System Readiness Checklist (Preliminary Version)

Installation:

All relays have been labeled per the project requirements.

All low voltage wiring has been installed in conduit per the project requirements.

Luminaries have been installed, aimed and adjusted as required.

All luminaries have cleaned and surfaces touched-up as required.

Photocells have installed in specified locations and photometric surfaces cleaned per the manufacturer recommendations.

All control wiring installed and complete.

Start-Up:

Commissioning Authority notified for witness of start-up.

Continuity testing complete.

Torque tests complete.

Grounding testing complete.

Voltage verification tests complete.

Lighting circuits have been verified.

Multi-level lighting has been verified.

Operational testing complete

Manufacturer start-up has been performed.

All above listed test reports are attached.

Readiness:

Manufacturer's installation and start-up procedures were followed.

As-built drawings have been updated and submitted.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The draft versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These draft Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A System Description	B Responsible Contractor	C Proposed Test Forms Received	D OK	E Testing Complete	F OK	G Notes
Power Distribution						
Engine Generator and Controls						
Uninterruptible Power Supply						
Lighting Control System						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Power Distribution
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	10%

Functional Tests:

1) Wiring Devices
   a) Continuity
   b) Polarity
   c) Ground
   d) GFI

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Engine Generator and Controls
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Functional Tests:

1) Power outage simulation including delays, timing

2) Loss of phase to ground voltage for each phase

3) Trending
   a) Kilowatts
   b) Amperes
   c) Voltage
   d) Coolant temperature
   e) Room temperature
   f) Frequency
   g) Oil pressure

4) Alarm Reporting

5) Sound Level Requirements

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Static Uninterruptible Power Supply
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Functional Tests:

Functional testing per 263353, 3.7

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Lighting Control System

Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule-B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1) Lighting Controls – Demonstrate and document the following:
   a) All features and functions of control panel
   b) On/Off control
   c) Battery operated emergency lighting on power failure
   d) Dimming control
   e) Manual overrides
   f) Scheduling programming
   g) Light zoning and channel verification

2) Occupancy Sensors – Demonstrate and document the following:
   a) Operation of all features and functions
   b) Sensitivity range
   c) Time delay setting
   d) On, Off and By-Pass Functions

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are draft versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	Responsible Contractor	Proposed Agenda Received	OK	Training Performed	OK	Closeout Form Received	OK	Notes
Power Distribution								
Engine Generator and Controls								
Uninterruptible Power Supply								
Lighting Control System								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Building IAQ flush out completed and accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

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Sample Draft Functional Performance Test
Electrical Panel Polarity, Continuity and Panel Schedule Test Sheet

1. Record Panel Number, Circuit Breaker Number and Description of area served.
2. Verify area served will not be affected by disconnecting power.
3. Insert continuity/polarity probe into outlet. Verify all indicators register normal.
4. Shut off circuit breaker and verify area served description is correct. Cross-reference with drawings as necessary.

Criteria: A – Polarity and Continuity OK B – Index is correct

Panel	CB	Description	A	B	Comment

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Sample Draft Functional Performance Test
Emergency Power System
Power Outage Simulation

Procedures:

1. Verify all systems are in the occupied mode and operating normally.
2. Trip building main utility breaker simulating a power outage.
3. Verify emergency generator starts.
4. Verify automatic transfer switch operates properly.
5. Verify systems and equipment on e-power operate.
6. Verify building emergency circuits using e-power panel circuit directory as a reference.
7. Re-establish utility power.
8. Verify automatic transfer switch recognizes utility power.
9. Verify generator shuts off after cool-down period.

Data Sheet

Description	Observation
Systems in occupied mode.	
Building main utility breaker tripped.	
Generator – ON	
Automatic transfer switch in emergency power position.	
Emergency egress lighting operational.	
Access control system operational.	
Fire alarm panel indicates on battery power.	
Equipment on e-power – ON	
Circuits verified.	
Re-establish utility power.	
Transfer switch indicates normal power available.	
Transfer switch transfers to utility power after time delay.	
Generator shuts down after cool down.	
Test Pass/Fail	

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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Sample Draft Functional Performance Test
Lighting Control
Occupancy Sensor Control

1. Verify and record occupancy delay time.
2. Verify wall switches (if applicable) are on.
3. Wait till rooms are unoccupied and lights are off.
4. Enter room and verify lights are activated.
5. Leave the room and measure time delay until lights go out.

Room:							
Occupancy delay time setting (minutes)							
Lights off when unoccupied ?							
Lights come on when room is entered ?							
Time delay until lights go out (minutes)							

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

END OF SECTION 260800

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SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS

A. Product Data: Include dimensions and data on features, components, and ratings for lighting control devices.

B. Samples: Occupancy sensors for color selection and evaluation of technical features.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For lighting control devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control devices from a single source with total responsibility for compatibility of lighting control system components specified in this Section, and in Division 13 Section "Lighting Controls."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:
   1. Division 26 Section "Panelboards."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Contactors and Relays:
      a. Cutler-Hammer Products; Eaton Corporation.
      b. GE Lighting Controls.
      c. Hubbell Lighting, Inc.
      d. Square D Co.; Power Management Organization.

   2. Time Switches:
      a. Tork, Inc.

   3. Photoelectric Relays:
      a. Tork, Inc.

   4. Occupancy Sensors:
      a. Sensor Switch.
      b. Hubbell Lighting, Inc.
      c. Novitas, Inc.
      d. Watt Stopper, Inc. (The).
      e. Mytech.

2.2 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

A. Line-Voltage Surge Protection: Include in all 120- and 277-V solid-state equipment. Comply with UL 1449 and with ANSI C62.41 for Category A locations.

2.3 TIME SWITCHES

A. Description: Solid-state programmable units with alphanumeric display complying with UL 917.

B. Description: Electromechanical-dial type complying with UL 917.

   1. Astronomic dial.

2. Two contacts, rated 30 A at 277-V ac, unless otherwise indicated.
3. Two pilot-duty contacts, rated 2 A at 240-V ac, unless otherwise indicated.
4. Eight-day program uniquely programmable for each weekday and holidays.
5. Skip-day mode.

2.4 PHOTOELECTRIC RELAYS

A. Description: Solid state, with single-pole, double-throw dry contacts rated to operate connected relay or contactor coils or microprocessor input, and complying with UL 773A.

B. Light-Level Monitoring Range: 0 to 3500 fc, with an adjustment for turn-on/turn-off levels.

C. Time Delay: Prevents false operation.

D. Indoor Ceiling- or Wall-Mounting Units: Adjustable for turn-on/turn-off levels, semiflush, calibrated to detect adequacy of daylighting in perimeter locations, and arranged to turn artificial illumination on and off to suit varying intensities of available daylighting.

E. Indoor Skylight Units: Housed in a threaded plastic fitting for mounting under skylight.

F. Outdoor Sealed Units: Weathertight housing, resistant to high temperatures and equipped with sun-glare shield and ice preventer.

2.5 OCCUPANCY SENSORS

A. Ceiling-Mounting Units: Unit receives control power from a separately mounted auxiliary power and control unit, and operates power switching contacts in that unit.

B. Switch-Box-Mounting Units: Unit receives power directly from switch leg of the 120- or 277-V ac circuit it controls and operates integral power switching contacts rated 800 W at 120-V ac, and 1000 W at 277-V ac, minimum.

C. Operation: Turns lights on when room or covered area is occupied and off when unoccupied, unless otherwise indicated.

1. Time Delay for Turning Lights Off: Adjustable over a range from 1 to 15 minutes, minimum.
2. Manual Override Switch: Turns lights off manually regardless of elapsed time delay.
3. Ambient-Light-Level Control: Adjustable for setting a level of ambient illumination above which sensor will not turn lights on when occupancy is sensed.
4. Isolated Relay Contact: Operates on detection of occupancy or vacancy, as indicated, to activate an independent function.

D. Auxiliary Power and Control Units: As follows:

1. Relays rated for a minimum of 20-A normal ballast load or 13-A tungsten filament or high-inrush ballast load.
2. Sensor Power Supply: Rated to supply the number of connected sensors.

E. Passive-Infrared Type: Detects occupancy by a combination of heat and movement in zone of coverage. Each sensor detects occupancy anywhere in an area of 1000 sq. ft. by detecting occurrence of 6-inch minimum movement of any portion of a human body that presents a minimum target of 36 sq. in. to the sensor.

F. Ultrasonic Type: Emits a beam of ultrasonic energy and detects occupancy through use of Doppler's principle in discerning movement in zone of coverage by sensing a change in pattern of reflected ultrasonic energy.

G. Dual-Technology Type: Uses a combination of passive-infrared and ultrasonic detection methods to distinguish between occupied and unoccupied conditions for area covered. Particular technology or combination of technologies that controls each function (on or off) is selectable in the field by operating controls on unit.

2.6 MULTIPOLE CONTACTORS AND RELAYS

A. Description: Electrically operated and mechanically held, and complying with UL 508 and NEMA ICS 2.

1. Current Rating for Switching: UL listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).
2. Control Coil Voltage: Match control power source.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment level and plumb and according to manufacturer's written instructions.

B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 26 Section " Common Work Results For Electrical."

C. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounting devices.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables" for low-voltage connections and Division 27 Section "Voice and Data Systems" for digital circuits.

B. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes for Electrical Systems," unless run in accessible ceiling space and gypsum board partitions.

D. Bundle, train, and support wiring in enclosures.

E. Ground equipment.

F. Connections: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section " Common Work Results For Electrical."

B. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Schedule visual and mechanical inspections and electrical tests with at least seven working days' advance notice.

B. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

C. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

D. Verify settings of photoelectric devices with photometer calibrated within previous six months.

E. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

F. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

G. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

H. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 DEMONSTRATION

A. Coordinate with training for low-voltage, programmable lighting control system specified in Division 13 Section "Lighting Controls."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of three hours' training.
2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested, to adjust light levels, make program changes, and adjust sensors and controls to suit actual conditions.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 260923

SECTION 261200 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:
   1. Pad-mounted, liquid-filled transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Wiring and connection diagrams including power wiring.

C. Coordination Drawings: Floor plans drawn to scale and coordinating floor penetrations and floor-mounted items. Show the following:

   1. Underground primary and secondary conduit stub-up location.
   2. Dimensioned concrete base, outline of transformer, and required clearances.
   3. Ground rod and grounding cable locations.

D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Follow-up service reports.

I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C2.

D. Comply with ANSI C57.12.28, IEEE C57.12.10, IEEE C57.12.70, and IEEE C57.12.80.

E. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.6 PROJECT CONDITIONS

A. Service Conditions: IEEE C37.121, usual service conditions except for the following:

1. Exposure to significant solar radiation.
2. Altitudes above 4500 feet.
3. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
4. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
5. Exposure to excessively high or low temperatures.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries; Cooper Power Systems Division.
2. Square D/Groupe Schneider NA.
3. GE
4. Siemens.
5.

2.2 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

A. Description: ANSI C57.12.13, IEEE C57.12.00, pad-mounted, 2-winding transformers.

B. Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

C. Insulation Temperature Rise: 65 deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.

D. Basic Impulse Level: 95 kV.

E. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

F. High-Voltage Switch: 200 A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for loop feed with 3-phase, 4-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.

G. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed circuits.

H. High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:

1. Bushing-Well Inserts: One for each high-voltage bushing well.
2. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
3. Parking Stands: One for each high-voltage bushing well.
4. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.

I. Accessories:

1. Drain Valve: 1 inch, with sampling device.
2. Dial-type thermometer.
3. Liquid-level gage.
4. Pressure-vacuum gage.
5. Pressure Relief Device: Self-sealing with an indicator.
6. Mounting provisions for low-voltage current transformers.
7. Mounting provisions for low-voltage potential transformers.

J. Winding:

1. Continuous copper winding.

2.3 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section " Common Work Results For Electrical."

2.4 SEISMIC RESTRAINTS

A. Design and fabricate transformers, and anchorage devices for them, to withstand static and seismic forces in any direction.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to applicable ANSI and IEEE requirements.

B. Factory Tests: Provide the following standard factory-certified tests:

1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
2. Ratios on rated-voltage connection and on tap extreme connections.
3. Polarity and phase relation on rated-voltage connection.
4. No-load loss at rated voltage on rated-voltage connection.
5. Excitation current at rated voltage on rated-voltage connection.
6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.

7. Applied potential.
8. Induced potential.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."
4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Common Work Results For Electrical."

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.2. Certify compliance with test parameters.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

D. Test Reports: Prepare written reports to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:

    a. Adjust transformer taps.

3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
4. Report: Prepare written report covering monitoring and corrective actions performed.

B. Infrared Scanning: Perform as specified in Division 26 Section "Medium-Voltage Switchgear."

3.7 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 261200

SECTION 261300 - MEDIUM VOLTAGE SWITCHGEAR

PART 1 - GENERAL

A. This specification covers the requirements for a manually operated, load and fault interrupting switch for pad-mount installation.

PART 2 - PRODUCTS

A. This specification applies to three-phase group-operated, 60hz, fully dead front sectionalizing switchgear; with maximum main ratings of 600 amperes continuous current. Three-phase group-operated over current protection shall be accomplished utilizing a reset table vacuum fault interrupter (VFI). Unit is to be of SF6 gas-insulated sealed tank design, so operation is unimpaired by flood conditions or contaminated environments. All current interruption shall be accomplished utilizing vacuum switches or vacuum fault interrupters, as appropriate. Unit shall be designed for installation on a pad at ground level. Switchgear must be in complete conformance with industry standard pad mount switchgear specification (ANSI C37.72). Vacuum fault interrupter shall meet duty cycle specified by ANSI C37.60, with additional requirements listed below:

PART 3 - ELECTRICAL RATINGS

Voltage Class	**15kV**
BIL	95kV
AC Withstand	34kV
Load-break and Continuous Current Rating (Symmetrical)	600A
Momentary and Fault Close Rating	
(Symmetrical)	12kA
(Asymmetrical)	20kA
VFI Interrupter Interrupting Rating	
(Symmetrical)	12kA
(Asymmetrical)	20kA

PART 4 - TRIP CONTROL (Type II Controller)

A. Over current sensing shall be accomplished with an electronic trip control. Control shall use current transformers to sense line currents. These current transformers shall also provide power for control operation. No external power source shall be required. To provide

immunity from system voltage problems (i.e. over-voltage transients) control shall not be sensitive to system voltage conditions. Control shall be fully operable and meet specified time-current curve immediately upon energization. No warm-up time, minimum load requirement, or battery back-up device shall be necessary.

B. Minimum trip settings shall be field selectable (in 12 setting) from 20 amps to 600 amps. Trip settings may be changed while the switchgear is energized (so service is not interrupted).

C. Time-current trip curves shall be changeable via dip switch settings, E standard speed.

D. Coordinate with transformer manufacturers for proper trip setting.

PART 5 - CONSTRUCTION

5.1 GENERAL DESIGN

A. Pad mounted, compartment type switchgear shall consist of a SF6 gas insulation sealed tank and separate main and tap compartments. Sealed tank shall be capable of withstanding flood immersion while energized, and shall not allow the ingress of any airborne contaminants. Main and tap cable compartments shall be located at front and back of tank, respectively. Main compartment shall house source bushings and source switch operating handles. Tap compartment shall house tap bushings and VFI operating handles. The unit shall be front accessible only

B. Cable compartments shall have a minimum depth of 16 inches when 200 ampere bushings are utilized.

C. Swing-up doors are required for entry into main and tap cable compartments.

D. Doors shall be secured with recessed pentahead bolts, with provisions for padlocking. Door hinges shall be provided with stainless steel pins.

E. Recessed lifting provisions for suitable balanced lift shall be provided.

F. Units shall be shipped complete with SF6.

G. Units shall be of bolted cover design, utilizing Buna-N rubber gaskets.

H. Units shall be equipped with an SF6-fill valve.

I. A 1/2"-13 ground nut shall be mounted beneath each bushing, in each compartment, for grounding.

J. Switchgear shall have an SF6 pressure gauge.

K. A non-corrosive operating diagram (one-line schematic) shall be affixed to the inside of the door, on both sides of the unit.

L. Source switch shall be pad lockable in both the open and close position.

5.2 VFI MECHANISM

A. The switchgear shall incorporate a vacuum fault interrupter. The device shall interrupt all fault currents up to the rated maximum. The interrupter shall be manually reset table, with no consumable parts (i.e. fuses).

B. As a safety precaution, the interrupter shall incorporate a trip-free mechanism to prevent the possibility of holding the interrupter closed under a faulted condition.

C. Fault interrupter shall act as a three-phase group-operated circuit breaker. An over-current condition on any one phase shall simultaneously trip all three phases.

D. The VFI interrupter shall serve as a three-phase group-operated load-break switch.

5.3 BUSHINGS

A. Source bushings shall be equipped with RTE 600 ampere dead-break bushings, and conform to ANSI/IEEE standard 386. Provide 600 A. Bolet elbows with grounding provisions per cable manufacturer.

B. Tap bushings shall be RTE 200 ampere bushing wells and inserts and conform to ANSI/IEEE standard 386. Provide 200 A. load break elbows with grounding provisions per cable manufacturer.

C. Bushings are to be mounted in-line and located at a height of 24 inches above the pad.

5.4 FINISH

A. The switchgear shall be finished with a green color conforming to Munsell 7GY 3.29/1.5 Green. The coating shall conform to ANSI standard C57.12.28.

1. 1000 hour 5% salt spray corrosion test per ASTM B117.

2. 1000 hour humidity test per ASTM D2247.

3. 500 hour ultraviolet accelerated weathering test per ASTM G53.

4. Impact per ASTM D2794.

5.5 PRODUCTION TESTING

A. The unit shall be subjected to the following production tests:

1. Continuity test to assure correct internal connections.

2. Hi-pot test to determine dielectric strength of the unit.

3. Pressure test to assure tank is completely sealed.

4. Electrical TCC trip test.

5.6 TEST DATA

A. Certified test data bearing the seal of a Registered Professional Engineer shall be available upon request for the following:

1. Switch ratings per ANSI C37.72.

2. Interrupter ratings per ANSI C37.60.

3. Coatings per ANSI C57.12.28.

5.7 APPROVED MANUFACTURERS

A. Cooper
B. G&W

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 261300

SECTION 262200 – LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.
2. Control and signal transformers.

1.3 SUBMITTALS

A. Product Data Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Wiring and connection diagrams.

C. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Output Settings Reports: Record of tap adjustments specified in Part 3.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with IEEE C 57.12.91.

C. Energy-Efficient Transformers Rated 15 kVA and Larger: Certified as meeting NEMA TP 1, Class 1 efficiency levels when tested according to NEMA TP 2.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of wall-mounting and structure-hanging supports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cutler-Hammer.
2. GE Electrical Distribution & Control.
3. Square D/Groupe Schneider NA.
4. Federal Pacific.
5. Siemens.

2.2 MATERIALS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices, except for taps.

1. Internal Coil Connections: Brazed or pressure type.

2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are internally braced to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, dripproof, NEMA 250, Type 3R.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Outdoor Transformer Enclosure Finish: Comply with NEMA 250 for "Outdoor Corrosion Protection."

1. Finish Color: Gray .

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature.

G. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.

H. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

J. Wall Brackets: Manufacturer's standard brackets.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls and floors for suitable mounting conditions where transformers will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Install floor-mounting transformers level on concrete bases. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 5 percent. Submit recording and tap settings as test results.

B. Adjust buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test

development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes service and distribution switchboards rated 600 V and less.

B. Related Sections include the following:

1. Division 26 Section "Fuses."
2. Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, TVSS device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.

b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of switchboards and overcurrent protective devices.
d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
e. Utility company's metering provisions with indication of approval by utility company.
f. Mimic-bus diagram.
g. UL listing for series rating of installed devices.
h. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration Seismic Controls for Electrical Systems." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event."
3. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."
4. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Samples: Representative portion of mimic bus with specified finish, for color selection.

E. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

F. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Manufacturer's field service report.

H. Updated mimic-bus diagram reflecting field changes after final switchboard load connections have been made, for record.

I. Maintenance Data: For switchboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards, including clearances between switchboards, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250-W per section) to prevent condensation.

D. Handle switchboards according to NEMA PB 2.1.

1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than seven working days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
2. Indicate method of providing temporary utilities.
3. Proceed with utility interruptions only after receiving Architect's written authorizations.

C. Environmental Limitations: Rate equipment for continuous operation under the following, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

D. Service Conditions: NEMA PB2, usual service conditions, as follows:

1. Altitude not exceeding 4000 feet.
2. Ambient temperatures within limits specified.

1.8 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Corp.; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Div.
3. Square D Co.
4. Siemens.

2.2 MANUFACTURED UNITS

A. Front-Connected, Front-Accessible Switchboard: Panel-mounted main device, panel-mounted branches, and sections rear aligned.

B. Nominal System Voltage: 480Y/277 V and 208 Y/120 V.

C. Main-Bus Continuous: As shown on the plans.

2.3 FABRICATION AND FEATURES

A. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

B. Barriers: Between adjacent switchboard sections.

C. Insulation and isolation for main and vertical buses of feeder sections.

D. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

E. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

F. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

G. Hinged Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.

H. Pull Box on Top of Switchboard: Include the following features:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

I. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
   a. use copper for feeder circuit-breaker line connections.

2. Load Terminals: Insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full ampere rating of circuit-breaker position.
3. Ground Bus: 1/4-by-2-inch minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Contact Surfaces of Buses: Silver plated.
5. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
7. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus is braced.

J. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

K. Bus-Bar Insulation: Factory-applied, flame-retardant, 105 deg C minimum tape wrapping of individual bus bars or flame-retardant, spray-applied insulation of same temperature rating.

2.4 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b"contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

C. Enclosed, Insulated-Case Circuit Breaker: Fully rated, encased-power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments with I^2t response.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Remote trip indication and control.
5. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system.
6. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
7. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
8. Control Voltage: 125- V ac.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems manufactured by Square-D Power Logic Model CM2350 and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Watt-Hour Meters: Flush or semiflush type, rated 5 A, 120 V, 3 phase, 3 wire, with 3 elements, 15-minute-indicating-demand register, and provision for testing and adding pulse initiation.

2.6 CONTROL POWER

A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

PART 3 - EXECUTION

3.1 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.2 EXAMINATION

A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Support switchboards on concrete bases, 4-inch nominal thickness.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section " Common Work Results For Electrical."

B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.5 CONNECTIONS

A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.8 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.9 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

1. Lighting and appliance branch-circuit panelboards.
2. Distribution panelboards.

B. Related Sections include the following:

1. Division 26 Section "Fuses."
2. Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, TVSS device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of panelboards and overcurrent protective devices.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event."
3. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."
4. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.7 EXTRA MATERIALS

A. Keys: one spares of each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:

a. Eaton Corp.; Cutler-Hammer Products.
b. General Electric Co.; Electrical Distribution & Control Div.
c. Square D Co.
d. Siemens.

2.2 FABRICATION AND FEATURES

A. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

F. Bus: Hard-drawn copper, 98 percent conductivity.

G. Main and Neutral Lugs: Compression type suitable for use with conductor material.

H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

I. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

J. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

K. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

L. Split Bus: Vertical buses divided into individual vertical sections.

M. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

N. Gutter Barrier: Arrange to isolate individual panel sections.

O. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

P. Feed-through Lugs: Compression type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

2.3 PANELBOARD SHORT-CIRCUIT RATING

A. UL label indicating series-connected rating with integral or remote upstream devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

B. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices: Circuit breaker.

C. Branch overcurrent protective devices shall be one of the following:

1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.

5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.7 CONTROLLERS

A. Motor Controllers: NEMA ICS 2, Class A combination controller equipped for panelboard mounting and including the following accessories:

1. Individual control-power transformers.
2. Fuses for control-power transformers.
3. Electronic overload relay.
4. Indicating lights, as shown.
5. Seal-in contact.
6. 2 convertible auxiliary contacts.
7. Push buttons.
8. Selector switches.

B. Contactors: NEMA ICS 2, Class A combination controller equipped for panelboard mounting and including the following accessories:

1. Individual control-power transformers.
2. Fuses for control-power transformers.
3. Indicating lights.
4. Seal-in contact.
5. 2 convertible auxiliary contacts.
6. Push buttons.
7. Selector switches.

C. Controller Disconnect Switches: Adjustable instantaneous-trip circuit breaker [integrally mounted] [mounted adjacent to] and interlocked with controller.

1. Auxiliary Contacts: Integral with disconnect switches to de-energize external control-power source.

D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.

1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. Control-Power Source: 120-V branch circuit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.

D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

F. Install filler plates in unused spaces.

G. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

H. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Common Work Results For Electrical."

B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.7 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262416

SECTION 262419 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes motor-control centers for use on ac circuits rated 600 V and less.

B. Related Sections include the following:
   1. Division 26 Section "Transient Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.
   2. Division 26 Section "Fuses" for fuses in fusible switches.

1.3 SUBMITTALS

A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each motor-control center.

   1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current ratings of buses and installed units.
      d. Vertical and horizontal bus capacities.
      e. UL listing for series rating of overcurrent protective devices in combination controllers.
      f. Features, characteristics, ratings, and factory settings of each motor-control center unit.

   2. Wiring Diagrams: Power, signal, and control wiring for class and type of motor-control center. Differentiate between manufacturer-installed and field-installed wiring. Provide schematic wiring diagram for each type of controller.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center layout and relationships between electrical components and adjacent

structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that motor-control centers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Written reports specified in Part 3.

G. Manufacturer's field service report.

H. Maintenance Data: For motor-control centers, all installed devices, and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for motor-control centers and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

I. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

J. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent testing agency with the experience and capability to satisfactorily conduct the testing indicated, as documented according to ASTM E 548.

C. Source Limitations: Obtain controllers of a single type through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Handle motor-control centers according to NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory-installed lifting provisions.

C. Store motor-control centers indoors in clean, dry space with uniform temperature to prevent condensation. Protect motor-control centers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. If stored in areas subjected to weather, cover motor-control centers to protect from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
2. Indicate method of providing temporary utilities.
3. Do not proceed with utility interruptions without Architect's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

D. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Motor-Control Centers with Manual and Magnetic Controllers:

      a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
      b. Eaton Corp.; Cutler-Hammer Products.
      c. General Electrical Distribution & Control.
      d. Rockwell Automation Allen-Bradley Co.; Industrial Control Group.
      e. Siemens/Furnas Controls.
      f. Square D Co.

   2. Motor-Control Centers with Variable-Frequency Controllers:

      a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
      b. Danfoss Inc.; Danfoss Electronic Drives Div.
      c. Eaton Corp.; Cutler-Hammer Products.
      d. General Electrical Distribution & Control.

e. MagneTek Drives and Systems.
f. Rockwell Automation Allen-Bradley Co.; Industrial Control Group.
g. Siemens/Furnas Controls.
h. Square D Co.

2.2 MOTOR-CONTROL CENTERS

A. Wiring: NEMA ICS 3, Class I, Type B.

B. Enclosures: Flush- or surface-mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
3. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center. Interchangeability of units requiring the same size compartment and constructed to permit ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
4. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.

C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location.

2.3 BUSES

A. Material: Plated copper.

B. Ampacity Ratings: As indicated for horizontal and vertical main buses.

C. Equipment Ground Bus: Noninsulated, horizontal copper bus 2 by 1/4 inch, minimum.

D. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.

E. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

2.4 FUNCTIONAL FEATURES

A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.

B. Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.

1. Install units with full-voltage, across-the-line, magnetic controllers up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.
3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or drawout terminal boards for external control connections.

C. Overcurrent Protective Devices: Individual feeder-tap units through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Transient Voltage Surge Suppressors: Connect to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

F. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."

2.5 MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Controller: Factory-assembled combination controller and disconnect switch.

1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.
2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

D. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

E. Multispeed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:

1. Compelling relay to ensure motor will start only at low speed.

2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
3. Decelerating relay to ensure automatically timed deceleration through each speed.

F. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.

G. Part-Winding Controller: NEMA ICS 2, closed transition with separate overload relays for starting and running sequences.

H. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.

I. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
3. LED indicators showing motor and control status, including the following conditions:

    a. Control power available.
    b. Controller on.
    c. Overload trip.
    d. Loss of phase.
    e. Shorted silicon-controlled rectifier.

4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
5. Motor running contactor operating automatically when full voltage is applied to motor.

2.6 FEEDER OVERCURRENT PROTECTION

A. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

4. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
5. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity.
6. Molded-Case Switch: Molded-case circuit breaker without trip units.

B. Molded-Case, Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage time delay.
7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts; "b"contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

C. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.

2.7 MOTOR-CONTROL CENTER ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

1. Ammeter: Output current, with current sensors rated to suit application.
2. Voltmeter: Output voltage.

3. Frequency Meter: Output frequency.

G. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display of the following:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

H. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

I. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

J. Spare-Fuse Cabinet: Identified cabinet with hinged lockable door.

2.8 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. See Division 26 Section "Common Work Results For Electrical" for general installation instructions.

B. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.

C. Install motor-control centers on concrete bases complying with Division 3 Section "Cast-in-Place Concrete."

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 IDENTIFICATION

A. Identify motor-control center, motor-control center components, and control wiring according to Division 26 Section "Common Work Results For Electrical."

B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where available.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.7 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
2. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting solid-state controllers.

D. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.8 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 CLEANING

A. Clean controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that motor-control centers and components are installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain motor-control centers.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.12 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262419

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Single and duplex receptacles, ground-fault circuit interrupters, integral surge suppression units, and isolated-ground receptacles.
2. Single- and double-pole snap switches and dimmer switches.
3. Device wall plates.
4. Pin and sleeve connectors and receptacles.
5. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. PVC: Polyvinyl chloride.

D. RFI: Radio-frequency interference.

E. TVSS (SP): Transient voltage surge suppressor (Surge Protected).

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Wiring Devices:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Mfg. Company Inc.
   c. Pass & Seymour/Legrand; Wiring Devices Div.

2. Wiring Devices for Hazardous (Classified) Locations:

   a. Crouse-Hinds/Cooper Industries, Inc.; Arrow Hart Wiring Devices.
   b. EGS/Appleton Electric Company.
   c. Killark Electric Manufacturing Co./Hubbell Incorporated.

3. Multioutlet Assemblies:

   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Wiremold Company (The).

4. Poke-Through, Floor Service Outlets and Telephone/Power Poles:

   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Pass & Seymour/Legrand; Wiring Devices Div.
   c. Thomas & Betts Corporation.
   d. Wiremold Company (The).

2.2 RECEPTACLES

A. Straight-Blade-Type Receptacles: Configuration 5-20R duplex receptacle, Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.

B. Straight-Blade and Locking Receptacles: Heavy -Duty grade.

C. Straight-Blade Receptacles: Specification grade.

D. GFCI Receptacles: Straight blade, feed -through type, Heavy-Duty grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- deep outlet box without an adapter.

E. Isolated-Ground Receptacles: Straight blade, Heavy-Duty grade, duplex receptacle, with equipment grounding contacts connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap.

1. Devices: Listed and labeled as isolated-ground receptacles.
2. Isolation Method: Integral to receptacle construction and not dependent on removable parts.

F. Industrial Heavy-Duty Pin and Sleeve Devices: Comply with IEC 309-1.

2.3 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, Heavy-Duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.4 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.5 SWITCHES

A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.

B. Snap Switches: Heavy -Duty grade, quiet type.

C. Combination Switch and Receptacle: Both devices in a single gang unit with plaster ears and removable tab connector that permit separate or common feed connection.

1. Switch: 20 A, 120/277-V ac.
2. Receptacle: NEMA WD 6, Configuration 5-20R.

2.6 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for All devices in all Spaces: 0.035-inch- thick, satin-finished stainless steel .

2.7 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type , dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6, Configuration 5-20R, gray finish, unless otherwise indicated.

2.8 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Service Outlet Assembly: Flush type with four simplex receptacles and space for two RJ-45 jacks cat 5e.
2. Size: Selected to fit nominal cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors; and a minimum of two, 4-pair, Category 5e voice and data communication cables.

2.9 MULTIOUTLET ASSEMBLIES

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

B. Raceway Material: Metal, with manufacturer's standard finish.

C. Wire: No. 12 AWG.

2.10 SERVICE POLES

A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.

1. Poles: Nominal 2.5-inch- square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
3. Finishes: Manufacturer's standard painted finish and trim combination.
4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors; and a minimum of four, 4-pair, Category 5 voice and data communication cables.
5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6, Configuration 5-20R units.
6. Voice and Data Communication Outlets: Four RJ-45 Category 5E jacks.

2.11 FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

2.12 Pre Selected Devices Table:

	Manufacturers	Receptacles Cat. No.	Switches Cat No.
a.	Hubbell Inc.	HBL5352-GY	1201-GY
b.	Leviton Mfg. Co. Inc.	5362-GY	1221-GY
c.	Pass & Seymour.	5362-GY	1201-GY

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies level, plumb, and square with building lines.

B. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.

C. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.

D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

E. Remove wall plates and protect devices and assemblies during painting.

F. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Common Work Results For Electrical."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black -filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, controllers, and motor-control centers; and spare fuse cabinets.

1.3 SUBMITTALS

A. Product Data: Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

B. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

C. Ambient Temperature Adjustment Information. If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses adjusted.

1. For each adjusted fuse, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

D. Maintenance Data: For tripping devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS

1. Not used.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.; Bussmann Div.
2. Gould Shawmut.
3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK5, time delay.

B. Other Branch Circuits: Class RK5, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare fuse cabinets.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

3.7 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:

1. Service disconnecting means.
2. Feeder and branch-circuit protection.
3. Motor and equipment disconnecting means.

B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.
2. Division 26 Section "Switchboards" for individually enclosed, fusible switches used as feeder protection.
3. Division 26 Section "Fuses" for fusible devices.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. RMS: Root mean square.

C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switch and circuit breaker.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Current and voltage ratings.
c. Short-circuit current rating.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Manufacturer's field service report.

F. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for components.
2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA AB 1 and NEMA KS 1.

C. Comply with NFPA 70.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fusible Switches:

a. Eaton Corp.; Cutler-Hammer Products.
b. General Electric Co.; Electrical Distribution & Control Division.
c. Square D Co.
d. Siemens.

2. Molded-Case Circuit Breakers:

a. Eaton Corp.; Cutler-Hammer Products.
b. General Electric Co.; Electrical Distribution & Control Division.
c. Square D Co.
d. Siemens.

3. Combination Circuit Breaker and Ground-Fault Trip:

a. Eaton Corp.; Cutler-Hammer Products.
b. General Electric Co.; Electrical Distribution & Control Division.
c. Square D Co.
d. Siemens.

4. Molded-Case, Current-Limiting Circuit Breakers:

    a. Eaton Corp.; Cutler-Hammer Products.
    b. General Electric Co.; Electrical Distribution & Control Division.
    c. Square D Co.
    d. Siemens.

5. Integrally Fused, Molded-Case Circuit Breakers:

    a. Eaton Corp.; Cutler-Hammer Products.
    b. General Electric Co.; Electrical Distribution & Control Division.
    c. Square D Co.
    d. Siemens.

2.2 ENCLOSED SWITCHES

A. Enclosed, Non-fusible Switch: NEMA KS 1, Type HD, with lockable handle.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 ENCLOSED CIRCUIT BREAKERS

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Unit Circuit Breakers: To be installed in the main panels, RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.
4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity.
5. Molded-Case Switch: Molded-case circuit breaker without trip units.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b"contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.4 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Common Work Results For Electrical."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
2. Test continuity of each line- and load-side circuit.

B. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switches and circuit breakers checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262816

SECTION 262923 - VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

B. Requirements of the following Division 26 sections apply to this section:

1. "Common Work Results For Electrical."

1.2 DESCRIPTION OF WORK

A. Extent of variable frequency drive (VFD) work is indicated by drawings, schedules and specified herein. Work includes complete installation.

1.3 MANUFACTURER QUALIFICATIONS

A. Acceptance manufacturers of VFD equipment shall meet the following requirements:

1. Suppliers of VFD Systems must be in the business of supplying Variable Frequency Drives and have a minimum of ten (10) years of experience in that business.

2. Manufacturer must have local service center with a factory spare parts inventory and factory service technician on call 24 hours per day.

3. Manufacturer shall provide a complete set of engineering drawings and consisting of, as a minimum, general arrangements, power wiring diagram, control wiring diagram and schematic of VFD System components and options.

4. The manufacturer shall provide three owners manuals consisting of catalog sheets listing actual component and part numbers. Manual shall also show test certificates, warranty and service personnel responsible for warranty. Each owners manual shall also contain the following:

Manufacturer information of equipment being supplied.
1. Connection information.
2. Start up procedure.
3. Fault reset instruction.
4. Wiring diagrams (power and control).
5. Parts list.
6. Test results.

7. Harmonic voltage and current distortion with unit off at the point of connection.
8. Harmonic voltage and current distortion with unit on line at 100% load.
9. Harmonic voltage and current distortion strip chart recordings.
10. Harmonic voltage and current distortion report.

5. Manufacturer of VFD Systems shall provide a harmonic voltage and current distortion report, completed by an independent test source, not associated with the supplier of the equipment, once unit is installed. Said report shall be in accordance with paragraph "HARMONIC DISTORTION REPORT" specified herein under the execution portion of this specification.

6. Manufacturer shall guarantee that current distortion, on the line side (input terminals) of the VFD does not exceed 20% (total current Harmonic distortion).

7. Manufacturer shall correct harmonic voltage and current distortion with reactor or filter, at his cost, to stay within the above limit.

8. After VFD unit is installed, manufacturer shall take harmonic voltage and current distortion readings as described above and provide actual strip chart recordings of same in owner's manual.

9. The manufacturer shall verify compatibility of each VFD unit with the motor being supplied under Division 22 and 23. The vendor shall be responsible for reviewing Division 22 and 23 specifications sections, plans and schedules related to motors prior to bid and shall notify the engineer at least 10 days prior to the bid of any discrepancies or incompatibilities between VFD units and motor characteristics.

10. The manufacturer shall provide VFD system start-up service and field training of owner's operations personnel. Factory start up to be provided by a certified factory technician who shall be a full time VFD service Tech not a sales person.

11. The supplier of the VFD equipment shall be on authorized local dealer or representative of the manufacturer located within 100 miles of the job site.

12. The variable frequency drive system shall consist of a solid-state adjustable frequency controller harmonic voltage and current distortion filter if needed to meet IEEE-519-1992 and performance installed energy efficient motor. The supplier will assume responsibility for matching motor and controller and warranty.

1.4 APPROVED MANUFACTURERS Subject to compliance with requirements, provide products manufactured by:

1. Mitsubishi.
2. Allan Bradley
3. Square D
4. GE Fuji
5. Motor Drives International

PART 2 - PRODUCTS

VARIABLE FREQUENCY DRIVES

2.1 GENERAL

A. Drives shall consist of the following major components:

1. Input rectifier section to supply fixed DC bus voltage
2. Phase-to-Phase and Phase-to-ground MOV protection
4. DC bus capacitors
5. Sine weighted PWM generating invertor section
6. Separate terminal blocks for control and power wiring

B. Input Power

1. The drive shall be capable of accepting facility power as specified in drawings. Variations of up to plus 10% or minus 15% of line voltage and plus or minus 2 HZ of line frequency shall be permitted without the drive shutting down on a fault.

2. Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault (depending on drive configuration).

3. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.

4. The drive efficiency at rated load and frequency shall be 98% or better.

5. The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load.

6. The drive shall not be sensitive to supplied power of one phase grounded (Delta) or referenced to earth ground (Wye) Power Systems. Ungrounded Power Distribution systems (Delta or Wye) will use isolation transformers for all drives.

C. Output Power

1. The variable frequency AC drive shall convert 3 phase, 60 Hertz input power to an adjustable AC frequency and voltage for controlling the speed of NEMA B Design, AC squirrel cage motors.

2. The drive shall produce a (sine weighted PWM) three phase output for the load.

3. The drive shall have sufficient capacity to provide speed control of the motor throughout the operating range as specified herein.

4. Unless otherwise specified, the standard drive output will be adjustable from 0 to 60 HZ.

5. Unless otherwise specified, the drive output voltage shall be adjustable from 0 to specified available voltage at 60 HZ.

6. Unless otherwise specified, the drive shall produce a reduced volts-per-hertz (V/HZ) ratio in the 60 HZ range and below. The drive shall supply a constant 208 Volts output when operating above 60 HZ.

7. The drive shall have a selectable constant V/HZ ration or configurable V/HZ ration. Drives shall have selectable pre-programmed V/HZ ratios and the capability of programming a custom V/HZ pattern.

8. Motor overloads shall sense motor speed and motor current. Overloads that do not sense these parameters are not acceptable.

2.2 APPLICATION

A. Provide drive units which are applicable to the load characteristics, i.e., pumps, fans, compressors, conveyors, etc., and which meet the following operating conditions:

1. Drives for Variable Torque loads (ex: Centrifugal Compressors or pumps and fans) shall have a manufacturers overload rating of 120% for 1 minute.
2. Drives shall perform at an altitude of 5000 feet above sea level and have an operating temperature range of -10 to 50 degrees C (open rating) at 100% load with a relative humidity of 5 to 95% (0 to 90%) (non-condensing).
3. Manufacturer to submit data sheet confirming overload and temperature ratings.

2.3 VARIABLE FREQUENCY DRIVE SYSTEM

A. Unless otherwise specified, provide a NEMA 1 enclosure for each variable frequency drive system. The enclosure shall be either wall mounted. Mount all components in a single enclosure including, but not limited to, the VFD unit, harmonic filter, contactors, door interlocked circuit breaker, static pressure or differential pressure transducer and controller and/or other items listed in specification or shown on the plans. All components shall be completely wired within the enclosure. Systems requiring mounting and interconnection of separate bypass enclosures or harmonic filter assemblies are not acceptable under this specification.

2.4 CONSTRUCTION

A. Provide and mount the variable frequency drive inverter unit on a removable panel within the enclosure along with all other components such that the panel is removable from enclosure for maintenance and part replacement.

B. Provide an "Industrial Machine Tool" control transformer equal to an Acme type TA complete with primary and secondary fusing. All control power for operator devices and customer connections shall be 120 Volts AC.

C. Provide a suitably sized enclosure that meets UL 508, NEMA/EEMAC, IEC 529, IP65 standards. Enclosures shall be Hoffman Engineering Company A-LP series or approved equal. Subplates shall be of painted with white enamel.

D. Provide door mounted, industrial, oil tight operator devices similar to Allen-Bradley 800T, 800E, 800M or 800R oiltight series.

E. Paint enclosure with high grade enamel, a minimum of 50-70 microns thick.

F. Provide an electrical shock warning label to warn personnel that a potential of electric shock exists.

G. Provide engraved labels on all operator and pilot devices.

H. Panel Shop to be UL 508 certified.

2.5 STANDARD CONTROL FEATURES

A. Provide the following standard features on all VFD units:

1. The VFD Unit shall be a solid state AC to DC convertor sinusoidal pulse-width modulation (PWM) type. The drive current rating shall be equal to or greater than the motor current rating the drive is supplying.

2. The Unit shall operate on the voltage indicated.

3. The drive shall contain an output frequency clamp such that minimum or maximum output frequency can be set at desired limits.

4. The VFD Unit shall have an adjustable acceleration and deceleration time setting adjustable from 1 second to 120 seconds.

5. The drive shall have a foldback current limiting circuit. During acceleration, the circuit shall automatically reduce the acceleration rate to a slower rate should the load inertia cause excessive currents.

6. The drive shall have a selectable deceleration voltage limiting circuit. The circuit shall extend the set deceleration ramp should the bus voltage approach high limits due to regeneration.

7. The drive shall have incrementally adjustable IR compensation boost. A selectable range for offsetting motor losses at low frequency operation shall be used to optimize motor torque for starting high inertia and high friction loads.

8. Drive operation shall be fully digital with microprocessor control of frequency, voltage and current.

9. The Invertor shall be provided with a door interlocked input disconnect motor circuit protector. The MCP shall provide trip adjustment range sufficient to start the motor across the line in the bypass mode (if bypass option is specified) and

normally be set for maximum protection in the VFD mode. The door mounted handle shall have provisions to lock in the off position.

B. The following door mounted operator controls shall be provided as a minimum:

1. Hand/Off/Auto Selector Switch
2. Local/Remote Selector Switch
3. Frequency Setting Speed Pot
4. Frequency Indication Meter
5. Power on Light
6. VFD Enable Light
7. VFD Fault Light
8. External Fault Light (Safeties interlock)
9. Numeric key-pad and 4 line text and graphic display.

C. When Bypass is specified:

1. Bypass Pilot Light
2. Drive/Off/Bypass Selector Switch

D. The Invertor shall have a minimum of the following protective features with a visual display indication:

1. Auxiliary Fault
3. Bus Under-voltage
5. Motor Stalled
6. Drive Over-temperature
7. Ground Fault
8. Output Short
9. Software Fault
10. EEPROM Error
11. Input Power Loss
12. Bus Over-voltage
13. Motor Overload
14. Operator Error
15. Drive Overcurrent
16. Transistor Short
17. Hardware Fault

E. The following termination points shall be provided on a terminal strip for field connections:

1. Safeties Interlock (N.C. Contacts)
2. Remote Start/Stop Contact (N.O. Contacts)
3. Remote VFD Fault Contacts (N.C.)
4. Remote VFD/Bypass Enable Contacts (N.O.)
5. Remote Electronic Signal Input

F. Auto Restart shall be initiated by means of an automatic time delayed restart after recovering from undervoltage or loss of power. the Invertor shall not automatically restart after overcurrent, overvoltage, over temperature, or any other damaging conditions, but shall require a manual restart.

G. Isolated signal conditioner card (0-5 VDC, 0-10 VDC or 4-20 mA capable of inversion. The controls Contractor will supply source of voltage or current to this input.

H. Bypass: The Invertor shall be provided with a manual bypass contactor arrangement for transfer to the feeder line to operate at constant speed. The contactors shall be

electrically and mechanically interlocked and provided with an adjustable motor overload relay.

I. Isolation: A VFD isolation method shall be provided to allow maintenance on the VFD while operating in the bypass mode. This feature is only provide if the bypass feature in furnished. It shall be pre-wired in the same enclosure and shall include contactors... Input disconnect MCP, motor overload, VFD/Bypass selector switch, and Bypass On light.

J. Drive Warning Pilot contact to provided a signal that unit is being operated outside rated limits of Voltage; the drive is in current limit; precharge is incomplete or the drive has detected a 10% rise in bus voltage while decelerating.

K. Line Reactors: Furnish and install new line reactors suitable for the applicable load, 3%minimum.

12. Programmable Automatic Restart: Provide hardware and software as needed, and program the VFD system to automatically attempt to restart up to 10 times when user-selectable fault conditions such as over-voltage or over-current, or any VFD fault occurs as follows:

    1. Upon recognizing a fault condition, the VFD system will close a contact indicating Auto-Restart in Progress@. If the restart attempt succeeds within programmed parameters, the VFD will automatically resume normal operation, and open the Auto-Restart in Progress@ contact, without requiring manual reset, or issuing alarm signal.

    2. If the automatic restart attempt fails, the VFD system will cease operation and issue a AVFD Fault@ alarm. (Refer to Programmable Automatic Bypass as listed in this specification for additional requirements, if applicable).

13. Programmable Automatic Bypass: Provide hardware and software as needed to allow user to select operation sequence of the Bypass circuit as follows:

    1. Provide door-mounted Automatic Bypass / Manual Bypass@ mode selector switch.

    2. Manual Bypass mode: Bypass is manually engaged via the door-mounted VFD/Bypass switch.

    3. Automatic Bypass mode: Bypass is engaged automatically after a VFD fault alarm is issued. This will engage if the VFD Automatic Restart attempt is unsuccessful.

2.6 ACVF DRIVE COMPONENT

A. All control printed circuit boards shall be dynamically tested for a minimum of 22 hours while heat cycled 1 hour at each temperature setting from 0 degree C to 60 degree C and back to 0 degree C.

B. All drives shall be burned in for a minimum of 24 hours, cycling load to simulate no load/full load and exercise drive power components.

C. The completed drive shall be functionally tested with a motor before shipment to assure proper operation per specification.

2.7 DRIVE SYSTEM TEST

A. Comply with NEC, NEMA and IEEE (Including Harmonic Standard IEEE-519-1992) Standards as applicable to wiring methods, construction and installation and operation of variable frequency drives. Comply with applicable requirements of UL 908, "Power Conversion Equipment". Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing Laboratories, Inc. Note: The entire unit shall carry this label, not just components. Prior to shipping, test each unit and provide a certified test report with each unit. Standard tests shall include:

B. Visual inspection: Consisting of checking unit enclosure, wiring, connections, fasteners, covers and locking mechanism.

C. High pot test: Two (2) X rated voltage plus 1000 volts AC for 60 Seconds shall be applied per UL 508 on all peripheral drive system power components (circuit breakers, contactors, motor overloads, line reactor, disconnect switches, etc.) as a complete package. A copy of test results shall be included in operation manuals.

- Motor Run Test
- Control Panel Devices: test all devices and lights
- Control Panel Devices: test additional equipment specified with VFD system.
- Special tests: As required and specified
- The drive panel assembly, complete with specified options, shall be tested with a motor load before shipment.

PART 3 - EXECUTION

3.0 SUBMITTALS

A. Product Data: Submit manufacturer's data on variable frequency drives.

B. Shop Drawings: Submit dimensional drawings of variable frequency drives showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general arrangement with incoming and outgoing conduit locations; schematic; connection diagram sufficient to install system.

3.1 MECHANICAL COORDINATION

A. Meet with the supplier of the mechanical equipment and determine the exact characteristics of the motors for which VFD's are to be provided. Verify the exact control requirements, including interface signal type, reversing/non-reversing drives, interlocks, etc.

3.2 INSTALLATION OF VARIABLE FREQUENCY DRIVES

A. Install variable frequency drives as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

3.3 ADJUST AND CLEAN

A. Inspect operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movement.

B. Touch-up scratched or marred surfaces to match original finish.

3.4 START-UP SERVICES

A. The supplier of the AC drive described herein, shall provide field start-up service by a full time authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up service shall include system check-out, start-up and system run, and "line voltage" testing. Provide written report to Engineer and Architect.

3.5 FIELD TESTING

A. Subsequent to wire/cable hook-up, energize variable frequency drives and demonstrate functioning of equipment in accordance with requirements. Provide the Engineer with test results showing harmonic distortion, power factor characteristics at 25%, 50%, and 100% load points. Measurements shall be performed in accordance with IEEE-519-1992 at the input terminals of VFD system.

3.6 HARMONIC DISTORTION REPORT

A. After installation is complete, measure the harmonic voltage and current distortion of each Variable Frequency Drive, both with the VFD unit off, with the VFD running at 50% operating speed and with the VFD running at highest operating speed. Take measurements on each phase (L_L and L-N) on the line side (input terminals) of the VFD.

B. If measurements exceed the limits (as specified on Page 2), install corrective reactors or filters and retake measurements after corrective equipment is installed.

C. Include all measurements (before and after) in the harmonic distortion report. Provide the Engineer with a copy of the harmonic distortion report.

D. The Harmonic Distortion test and report shall be conducted by an approved independent testing agency. The cost of this service shall be included as part of the Drive Vendor's quotation. Approval shall be obtained from the Engineer prior to bidding this project.

F. VFD/Generator Harmonic Mitigation Responsibility
A licensed and qualified PE shall provide calculations that show THDVS is less than or equal to 10% on generator and guarantee generator stability with VFD filters and shall provide full document calculations. VFD manufacturer shall be responsible for all addition filters, etc as required to accomplish this.

3.7 OPERATION AND MAINTENANCE MANUALS

A. The vendor shall supply three (3) complete sets of engineering drawings consisting of, as a minimum, general arrangement, power wiring diagram, control wiring diagram and schematic of VFD System components and options, in accordance with general conditions of this specification.

3.8 VFD/GENERATOR HARMONIC MITIGATION RESPONSIBILITY

A. A licensed and qualified Professional Engineer (PE) shall provide calculations that show THDVS less than 10% on generator and guarantee generator stability with VFD filters and shall provide full documented calculations.

3.9 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 262923

SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1. RELATED DOCUMENTS

a. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

2. SUMMARY

a. This Section includes packaged diesel-engine generator sets with the following features and accessories:

1) Battery charger.
2) Skit mounted sub-base fuel tank.
3) Engine generator set.
4) Muffler.
5) Exhaust piping external to set.
6) Starting battery.

3. DEFINITIONS

a. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.

b. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

c. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

4. SUBMITTALS

a. Product Data: Include data on features, components, ratings, and performance. Include the following:

1) Dimensioned outline plan and elevation drawings of engine generator set and other components specified.
2) Thermal damage curve for generator.
3) Time-current characteristic curves for generator protective device.

b. Shop Drawings: Indicate fabrication details, dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1) Design Calculations: Use manufacturer standard isolation specification.
2) Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
3) Wiring Diagrams: Detail wiring for power and control connections and differentiate between factory-installed and field-installed wiring.

c. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

d. Field Test and Observation Reports: Indicate and interpret test results and inspection records relative to compliance with performance requirements.

e. Certified summary of prototype-unit test report.

f. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

g. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.

h. Factory Test Reports: For units to be shipped for this Project, showing evidence of compliance with specified requirements.

i. Exhaust Emissions Test Report: To show compliance with applicable regulations.

j. Sound or noise measurement test report.

k. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.

l. Field test report of tests specified in Part 3.

m. Maintenance Data: For each packaged engine generator and accessories to include in maintenance manuals specified in Division 1. Include the following:

1) List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
2) Detail operating instructions for both normal and abnormal conditions.

5. QUALITY ASSURANCE

a. Manufacturer Qualifications: Maintain a service center capable of emergency maintenance and repairs at the Project with eight hours' maximum response time.

b. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

c. Source Limitations: Obtain packaged engine generator and auxiliary components specified in this Section through one source from a single manufacturer.

d. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

e. Comply with NFPA 70.

f. Comply with NFPA 99.

g. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

h. Comply with NFPA 110 requirements for Level 2 emergency power supply system.

i. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

j. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of the installation.

6. DELIVERY, STORAGE, AND HANDLING

a. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

7. WARRANTY

a. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

b. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace packaged engine generator and auxiliary components that fail in materials or workmanship within specified warranty period.

1) Warranty Period: Two (2) years parts and labor from date of Substantial Completion.

8. MAINTENANCE SERVICE

a. Maintenance: At Substantial Completion, begin 12 months' full maintenance by skilled employees of the manufacturer's designated service organization. Include quarterly exercising to check for proper, starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in the manufacture and installation of original equipment.

9. EXTRA MATERIALS

a. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1) Fuses: One for every ten of each type and rating, but not less than one of each.
2) Indicator Lamps: Two for every six of each type used, but not less than two of each.
3) Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

1. MANUFACTURERS

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Caterpillar, Inc.; Engine Div.
2) Onan Corp; Industrial Business Group.
3) Kohler
4) Generac.
5) Detroit Deisel.

2. ENGINE GENERATOR SET

a. Furnish a coordinated assembly of compatible components.

b. Output Connections: Three phase, four wire.

c. Safety Standard: Comply with ASME B15.1.

d. Nameplates: Each major system component is equipped with a conspicuous nameplate of component manufacturer. Nameplate identifies manufacturer of origin and address, and model and serial number of item.

e. Resistance to Seismic Forces: Supports for internal and external components, and fastenings for batteries, wiring, and piping are designed and constructed to withstand static or anticipated seismic forces, or both, in any direction. For each item, use a minimum force value equal to weight of item.

f. Limiting dimensions indicated for system components are not exceeded.

g. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.

h. Skid: Adequate strength and rigidity to maintain alignment of mounted components without depending on a concrete foundation. Skid is free from sharp edges and corners. Lifting attachments are arranged to facilitate lifting with slings without damaging any components.

i. Rigging Diagram: Inscribed on a metal plate permanently attached to skid. Diagram indicates location and lifting capacity of each lifting attachment and location of center of gravity.

3. GENERATOR-SET PERFORMANCE

a. Steady-State Voltage Operational Bandwidth: 4 percent of rated output voltage from no load to full load.

b. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

c. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage recovers to remain within the steady-state operating band within three seconds.

d. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

e. Steady-State Frequency Stability: When system is operating at any constant load within rated load, there are no random speed variations outside the steady-state operational band and no hunting or surging of speed.

f. Transient Frequency Performance: Less than 5 percent variation for a 50 percent step-load increase or decrease. Frequency recovers to remain within the steady-state operating band within five seconds.

g. Output Waveform: At no load, harmonic content measured line to line or line to neutral does not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.

h. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, the system will supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to any generator system component.

i. Start Time: Comply with NFPA 110, Type 10, system requirements.

4. GENERATOR-SET PERFORMANCE FOR SENSITIVE LOADS

a. Oversizing generator compared with the rated power output of the engine to meet performance requirements in paragraphs below is permissible.

1) Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

b. Steady-State Voltage Operational Bandwidth: 2 percent of rated output voltage from no load to full load.

c. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

d. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage recovers to remain within the steady-state operating band within 0.5 second.

e. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

f. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there are no random speed variations outside the steady-state operational band and no hunting or surging of speed.

g. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency recovers to remain within the steady-state operating band within three seconds.

h. Output Waveform: At no load, harmonic content measured line to neutral does not exceed 2 percent total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.

i. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, the system will supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or any other generator system component.

j. Excitation System: Performance is unaffected by voltage distortion caused by nonlinear load.

k. Start Time: Comply with NFPA 110, Type 10, system requirements.

5. SERVICE CONDITIONS

a. Environmental Conditions: Engine generator system withstands the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1) Ambient Temperature: 5 to 40 deg C.
2) Ambient Temperature: Minus 15 to plus 40 deg C.
3) Relative Humidity: 0 to 95 percent.
4) Altitude: Sea level to 5000 feet.

b. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1) High salt-dust content in the air due to sea-spray evaporation.

6. ENGINE

a. Comply with NFPA 37.

b. Fuel: Fuel oil, Grade DF-2.

c. Rated Engine Speed: 1800 rpm.

d. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

e. Lubrication System: Pressurized by a positive-displacement pump driven from engine crankshaft. The following items are mounted on engine or skid:

1) Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2) Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit is capable of full flow and is designed to be fail-safe.
3) Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps or siphons or special tools or appliances.

f. Engine Fuel System: Comply with NFPA 37. System includes the following:

1) Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2) Relief/Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

g. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment.

7. GOVERNOR

a. Type: Adjustable isochronous, with speed sensing Electronic.

8. ENGINE COOLING SYSTEM

a. Description: Closed loop, liquid cooled, with radiator factory mounted on engine generator-set skid and integral engine-driven coolant pump.

b. Description: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.

c. Radiator: Rated for specified coolant.

d. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

e. Expansion Tank: Constructed of welded steel plate and equipped with gage glass and petcock.

f. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

g. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

1) Rating: 50-psig maximum working pressure with 180 deg F coolant, and noncollapsible under vacuum.
2) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

h. Coolant piping external to engine generator set. Use ASTM B 88, Type L copper tubing with brazed joints, sized as recommended by diesel engine manufacturer. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation and joint construction. Refer to Division 15 Section "Hydronic Piping" for materials and installation requirements for piping.

9. FUEL SUPPLY SYSTEM

a. Comply with NFPA 30 and NFPA 37.

b. Base-Mounted Fuel Oil Tank: Factory-installed and -piped, listed and labeled fuel oil tank. Features include the following:

1) Tank level indicator.
2) Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3) Vandal-resistant fill cap.
4) Containment Provisions: Comply with requirements of authorities having jurisdiction. Provide sensors and tie them to the generator control panel.
5) Dual wall.

10. ENGINE EXHAUST SYSTEM

a. Muffler: Critical type, sized as recommended by engine manufacturer. Measured sound level at a distance of 23 feet from exhaust discharge, is 87 dBA or less.

b. Condensate Drain for Muffler: Schedule 40, black steel pipe connected to muffler drain outlet through a petcock.

c. Connections from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.

d. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liners.

e. Supports for Muffler and Exhaust Piping: Spring hangers and all-thread rods and vibration hangers.

f. Exhaust Piping External to Engine: ASTM A 53, Schedule 40, welded, black steel, with welded joints and fittings.

11. COMBUSTION-AIR-INTAKE

a. Description: Heavy-duty engine-mounted air cleaner with replaceable dry filter element and "blocked filter" indicator.

12. STARTING SYSTEM

a. Description: 24-V electric, with negative ground and including the following items:

1) Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above.
2) Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3) Cranking Cycle: As required by NFPA 110 for system level specified.
4) Cranking Cycle: 60 seconds.
5) Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above to provide specified cranking cycle at least twice without recharging.
6) Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above to provide specified cranking cycle at least three times without recharging.
7) Battery Cable: Size as recommended by generator set manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
8) Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater is arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above. Include accessories required to support and fasten batteries in place.
9) Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
10) Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit complies with UL 1236 and includes the following features:

a) Operation: Equalizing-charging rate of 10 A is initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit then automatically switches to a lower float-charging mode and continues operating in that mode until battery is discharged again.
b) Automatic Temperature Compensation: Adjusts float and equalizes voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
c) Automatic Voltage Regulation: Maintains output voltage constant regardless of input voltage variations up to plus or minus 10 percent.
d) Ammeter and Voltmeter: Flush mounted in door. Meters indicate charging rates.
e) Safety Functions: Include sensing of abnormally low battery voltage arranged to close contacts providing low battery voltage indication on control and monitoring panel. Also include sensing of high battery voltage and loss of ac input or dc output of battery charger. Either condition closes contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

13. CONTROL AND MONITORING

a. Functional Description: When the mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic-transfer

switches initiate starting and stopping of the generator set. When the mode-selector switch is switched to the on position, the generator set manually starts. The off position of the same switch initiates generator-set shutdown. When the generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

b. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components are grouped in a combination control and power panel. Control and monitoring section of panel is isolated from power sections by steel barriers.

c. Indicating and Protective Devices and Controls: Include those required by NFPA 110 for a Level 1 system, and the following:

d. Indicating and Protective Devices and Controls: Include the following:

1) AC voltmeter.
2) AC ammeter.
3) AC frequency meter.
4) DC voltmeter (alternator battery charging).
5) Engine-coolant temperature gage.
6) Engine lubricating-oil pressure gage.
7) Running-time meter.
8) Ammeter-voltmeter, phase-selector switch(es).
9) Generator-voltage adjusting rheostat.
10) Start-stop switch.
11) Overspeed shutdown device.
12) Coolant high-temperature shutdown device.
13) Coolant low-level shutdown device.
14) Oil low-pressure shutdown device.
15) Fuel tank derangement alarm.
16) Fuel tank high-level shutdown of fuel supply alarm.
17) Generator overload.

e. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items on engine, generator, or elsewhere as indicated. Where not indicated, locate to suit manufacturer's standard.

f. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data link transmission of indications to remote data terminals. Data system connections to terminals are for future use only.

14. GENERATOR OVERCURRENT AND FAULT PROTECTION

a. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1) Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.

2) Trip Settings: Matched to generator thermal damage curve as closely as possible.
3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4) Mounting: Adjacent to or integrated with control and monitoring panel.

b. Generator Protector: Microprocessor-based unit that continuously monitors current level in each phase of generator output, integrates generator heating effect over time, and predicts when thermal damage of the alternator will occur. When signaled by the protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from the load circuits. Protector performs the following functions:

1) Initiates a generator overload alarm when the generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2) Under single or three-phase fault conditions, regulates the generator to 300 percent of rated full-load current for up to 10 seconds.
3) As heating effect on the generator of overcurrent approaches the thermal damage point of the unit, the protector switches the excitation system off, opens the generator disconnect switch, and shuts down the generator set.
4) Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

c. Ground-Fault Indication: Comply with NFPA 70, Article 700-7(d). Integrate ground-fault alarm indication with other generator-set alarm indications.

15. GENERATOR, EXCITER, AND VOLTAGE REGULATOR

a. Comply with NEMA MG 1 and specified performance requirements.

b. Drive: Generator shaft is directly connected to engine shaft. Exciter is rotated integrally with generator rotor.

c. Electrical Insulation: Class H or Class F.

d. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

e. Construction prevents mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

f. Excitation uses no slip or collector rings, or brushes, and is arranged to sustain generator output under short-circuit conditions as specified.

g. Enclosure: Dripproof.

h. Instrument Transformers: Mounted within generator enclosure.

i. Voltage Regulator: Solid-state type, separate from exciter; providing performance as specified.

1) Digital adjustment control and monitoring panel provides plus or minus 5 percent adjustment of output- voltage operating band.

j. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

k. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

l. Subtransient Reactance: 20 percent, maximum.

16. OUTDOOR GENERATOR-SET ENCLOSURE

a. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels are lockable and provide adequate access to components requiring maintenance. Panels are removable by one person without tools. Instruments and control are mounted within enclosure.

b. Description: Prefabricated enclosure with the following features:

1) Construction: Manufacturer standard.
2) Structural Design and Anchorage: Adequate to resist loads imposed by 100-mph wind.
3) Motorized Louvers: Equipped with insect/rodent screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust and rodents. Tie to the control panel per manufacturer recommendations.
4) Hinged Doors: With padlocking provisions of locking doors.
5) Ventilation: Louvers equipped with insect/rodent screen and filter arranged to permit air circulation while excluding exterior dust and rodents.
6) Thermal Insulation: As required to maintain winter interior temperature within 40 degree Fahrenheit. Provide heaters for enclosure and engine block heaters to be pre-wired and shall be tied to a 100 amps panel inside the enclosure. Contractor shall provide 100 amps 4-wire feeder to this panel from the nearest main distribution panel. Install the panel inside the enclosure.
7) Finish: Two-coat enamel finish over cleaned and primed surfaces.

c. Muffler Location: External to enclosure.

d. Engine Cooling Airflow through Enclosure: Adequate to maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

e. Louvers: Fixed-engine cooling air inlet and discharge. Louvers prevent entry of rain and snow.

f. Automatic Dampers: At engine cooling air inlet and discharge. Dampers are closed to reduce enclosure heat loss in cold weather when unit is not operating.

g. Convenience Outlets: Factory wired. Arrange for external circuit supply.

17. FINISHES

a. Outdoor Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

18. SOURCE QUALITY CONTROL

a. Factory Tests: Include prototype testing and Project-specific equipment testing (testing of equipment manufactured specifically for this Project).

b. Prototype Testing: Performed on a separate engine generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1) Tests: Comply with those required for Level 1 energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2 of NFPA 110.
2) Generator Tests: Comply with IEEE 115.
3) Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype have been tested to demonstrate compatibility and reliability.

c. Project-Specific Equipment Tests: Factory test engine generator set and other system components and accessories before shipment. Perform tests at rated load and power factor. Include the following tests.

1) Full load run.
2) Maximum power.
3) Voltage regulation.
4) Transient and steady-state governing.
5) Single-step load pickup.
6) Safety shutdown.

d. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

1. EXAMINATION

a. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

1) Proceed with installation only after unsatisfactory conditions have been corrected.

b. Examine roughing-in of cooling-system piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

2. CONCRETE BASES

a. Install concrete bases of dimensions indicated for packaged engine generators. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 26 Section "Common Work Results For Electrical."

3. INSTALLATION

a. Comply with packaged engine generator manufacturers' written installation and alignment instructions, and with NFPA 110.

b. Set packaged engine generator set on concrete bases.

1) Support generator-set mounting feet on rectangular metal blocks and shims or on metal wedges having small taper, at points near foundation bolts to provide 3/4- to 1-1/2-inch gap between pump base and foundation for grouting.
2) Adjust metal supports or wedges until generator is level.

c. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

d. Install cooling-system piping, accessories, hangers and supports, and anchors for complete installation.

1) Extend drain piping from heat exchangers to point of disposition.

e. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Size piping according to manufacturer's written instructions.

f. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system and from muffler to condensate traps and to point of disposition.

g. Install flow meters and sensors where indicated. Install flow-measuring system components and make connections according to manufacturer's written instructions.

h. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

1) Verify that electrical wiring is installed according to manufacturers' submittal and installation requirements in Division 26 Sections. Proceed with equipment startup only after wiring installation is satisfactory.

4. CONNECTIONS

a. Piping installation requirements are specified in Division 230553 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1) Install piping adjacent to packaged engine generator to allow service and maintenance.
2) Connect water supply to cooling system.
3) Connect cooling-system water supply and drain piping to diesel-engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.

4) Connect exhaust-system piping to diesel engines.

b. Electrical wiring and connections are specified in Division 26 Sections.

c. Ground equipment.

1) Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

5. IDENTIFICATION

a. Identify system components according to Division 22 and 23 Section "Mechanical Identification" and Division 26 Section "Identification for Electrical Systems."

6. FIELD QUALITY CONTROL

a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to assist in testing. Report results in writing.

b. Testing: Perform field quality-control testing under the supervision of the manufacturer's factory-authorized service representative.

c. Tests: Include the following:

1) Tests recommended by manufacturer.

2) Fuel Test: Engine supplier shall provide a full the fuel gas tank and shall test the fuel prior running the generator engine for any contimination and impurities. Provide copy of this test to the Owner and Engineer.
3) InterNational Electrical Testing Association Tests: Perform each visual and mechanical inspection and electrical and mechanical test stated in NETA ATS for emergency engine generator sets, except omit vibration baseline test. Certify compliance with test parameters for tests performed.
4) NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, the following:

a) Single-step full-load pickup test.

5) Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
6) Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

7) System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
8) Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40 inches wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
9) Exhaust Emissions Test: Comply with applicable government test criteria 2007 and shall comply with new tier requirement criteria established by the EPA.
10) Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
11) Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
12) Load Test: Provide minimum of 2 hour load test; ½ hour at 25% load, ½ hour at 50% load, and 1 hour at 100% load. Provide all means for a complete test. If any failure during the test, make corrections and repeat the test. Contractor is responsible for providing the fuel.

d. Coordinate tests with tests for transfer switches and run them concurrently.

e. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

f. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

g. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.

h. At the end of all testing, engine supplier shall provide full fuel tank to the owner and retest the fuel as required per C-2.

7. BATTERY EQUALIZATION

a. Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

8. CLEANING

a. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

9. DEMONSTRATION

a. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:

1) Coordinate this training with that for transfer switches.
2) Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
3) Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4) Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
5) Schedule training with Owner, through Architect, with at least seven days' advance notice.
6) Minimum Instruction Period: Eight hours.

4.0 GENERATOR/VFD HARMONIC MITIGATION RESPONSIBILITY

A. A licensed Professional Engineer (PE) shall provide calculations that show THDVS less than 10% on generator and guarantee generator stability with VFD filters and shall provide fully documented calculations.

4.1 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 263213

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes three-phase, on-line, static-type, UPS installations, complete with transient voltage surge suppression, input harmonics reduction, rectifier-charger, battery, battery disconnect device, inverter, static bypass transfer switch, internal maintenance bypass/isolation switch, external maintenance bypass/isolation switch, output isolation transformer, remote UPS monitoring provisions, battery monitoring.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. LCD: Liquid-crystal display.

C. LED: Light-emitting diode.

D. THD: Total harmonic distortion.

E. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

A. Product Data: Include data on features, components, ratings, and performance for each uninterruptible power supply component indicated.

B. Shop Drawings: Detail assemblies of equipment indicating dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.

1. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring. Differentiate between field-installed and factory-installed wiring and components.

C. Manufacturer Seismic Qualification Certification: Submit certification that UPS equipment will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Factory Test Reports: Comply with specified requirements.

G. Field Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

H. Maintenance Data: For UPS units to include in maintenance manuals specified in Division 1. Include the following:

1. Lists of spare parts and replacement components recommended being stored at Project site for ready access.
2. Detailed operating instructions covering operation under both normal and abnormal conditions.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of UPS manufacturer for both installation and maintenance of units required for this Project.

B. Power Quality Consultant Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET level 4, minimum, experienced in functional performance testing UPS installations and in performing power quality surveys similar to that required in Part 3 "Functional Performance Testing" Article.

C. Manufacturer Qualifications: A firm who maintains a service center capable of providing training, parts, and emergency maintenance and repairs for equipment at Project site with eight hours' maximum response time.

D. Source Limitations: Obtain the UPS and associated components specified in this Section from a single manufacturer with responsibility for entire UPS installation.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

1. UPS Units: Listed and labeled under UL 1778.
2. Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.

B. Store equipment in spaces with environments controlled within manufacturers' ambient temperature and humidity tolerances for nonoperating equipment.

1.7 WARRANTY

A. Warranties, General: Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Battery Warranties: Written warranty, signed by manufacturer and Installer agreeing to replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Sealed Lead-Acid Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	1 minute	1.67	120 cycles

C. Special UPS Warranties: Written warranties, signed by manufacturer and Installer agreeing to replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Three years from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.

1. Fuses: One for every 10 of each type and rating, but not less than 1 of each.
2. Cabinet Ventilation Filters: One complete set.
3. One spare circuit board for each critical circuit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Products: Subject to compliance with requirements, provide products by one of the following:
1. Chloride
2. Liebert Corp.
3. MGE-UPS Systems, Inc.
4. Mitsubishi Electric Automation Div.
5. APC.

2.2 FUNCTIONAL DESCRIPTION

A. Automatic operation includes the following:

1. Normal Conditions: Supply the load with ac power flowing from the normal ac power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
2. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter ac power output to the load without switching or disturbance.
3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated ac power to the load without switching or disturbance.
4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
5. If battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to a float-charge mode.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption of supply.
7. If a fault occurs in the system supplied by the UPS and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.

8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the load to be transferred by the static bypass transfer switch directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in the bypass mode. Device provides manual selection between the following three conditions without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and UPS rectifier-charger and inverter, or the battery and the inverter.

2.3 SERVICE CONDITIONS

A. Environmental Conditions: UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
3. Relative Humidity: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 5000 feet.

2.4 PERFORMANCE REQUIREMENTS

A. UPS shall perform as specified in this Article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.

4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 50 percent unbalanced continuously.

B. Minimum Duration of Supply: If battery is sole energy source supplying UPS-rated full-output load current at 80 percent power factor, duration of supply is 5 minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 20 percent from nominal voltage.

D. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

E. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

F. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD, maximum, at full-rated UPS load current, for power sources with X/R ratio between 2 and 30.
2. Description: THD is limited to a maximum of 32 percent, at full-rated UPS load current, for power sources with X/R ratio between 2 and 30.

G. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.

H. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent RMS total and 3 percent RMS for any single harmonic for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

I. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of full-load rating for 10 minutes, and 150 percent for 10 seconds in all operating modes.

J. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:

1. 50 Percent: Plus or minus 8 percent.
2. 100 Percent: Plus or minus 10 percent.
3. Loss of AC Input Power: Plus or minus 5 percent.
4. Restoration of AC Input Power: Plus or minus 5 percent.

K. Input Power Factor: A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and UPS is supplying rated full-load current.

L. EMI Emissions: Comply with FCC Rules and Regulations, 47 CFR 15 for Class A equipment.

2.5 SYSTEM COMPONENTS, GENERAL

A. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

B. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

C. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

D. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to specification.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.

E. Maintainability Features: Mount rectifier-charger and inverter sections and static bypass transfer switch on modular plug-ins, readily accessible for maintenance.

F. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.

G. Seismic-Restraint Design: UPS assemblies, subassemblies, and components; and fastenings and supports, mounting, and anchorage devices for them, shall be designed and fabricated to withstand static and seismic forces in any direction.

H. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of the cabinet and discharge it near the top rear.

I. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.6 RECTIFIER-CHARGER

A. Capacity: Adequate to supply the inverter during full-rated output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Rectifier-Charger Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.7 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output.

B. Description: Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.8 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full-load current of the UPS, minimum.

2.9 BATTERY

A. Description: Sealed, valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, and complete with battery disconnect switch.

B. Description: Sealed, premium, heavy-duty, valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for test and inspection.

C. Description: Wet-cell, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on three-tier, acid-resistant, painted steel racks. Assembly includes a battery disconnect switch, intercell connectors, a hydrometer syringe, and a thermometer with specific gravity-correction scales.

2.10 UPS CONTROL AND INDICATION

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include an audible signal and a visual display.

C. Indications: Plain-language messages on a digital LCD or LED.

1. Quantitative indications shall include the following:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time-discharging battery.

2. Basic status condition indications shall include the following:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition exists.

3. Alarm indications shall include the following:

a. Bypass ac input overvoltage or undervoltage.
b. Bypass ac input overfrequency or underfrequency.
c. Bypass ac input and inverter out of synchronization.
d. Bypass ac input wrong-phase rotation.
e. Bypass ac input single-phase condition.
f. Bypass ac input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.

aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

2.11 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be interlocked to prevent interrupting power to the load when switching to the bypass mode.
2. Switch shall isolate other UPS components electrically to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full-load current of UPS.

D. Mounting Provisions: Internal to system cabinet.

E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by static bypass transfer switch. Lock is designed specifically for electrical component interlocking.

2.12 OUTPUT ISOLATION TRANSFORMER

A. Description: Shielded unit with low forward transfer impedance up to 3 kHz, minimum. Include the following features:

1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 20.

2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
3. Regulation: 5 percent, maximum, at rated nonlinear load current.
4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
5. Electrostatic Shielding of Windings: Independent for each winding.
6. Coil Leads: Physically arranged for minimum interlead capacitance.
7. Shield Grounding Terminal: Separately mounted. Labeled, "Shield Ground."
8. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHZ.

2.13 OUTPUT DISTRIBUTION SECTION

A. Panelboard: Comply with Division 26 Section "Panelboards," except provide assembly integral to a UPS cabinet.

2.14 UPS MONITORING BY REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.15 MONITORING BY REMOTE COMPUTER

A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "UPS Control and Indication" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. Connectors and network interface units or modems for data transmission via RS-232 link.
2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Design for windows application in an IBM-compatible computer, which is not included in this Section.

2.16 BASIC BATTERY MONITORING

A. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

B. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

C. Annunciation of Alarms: At UPS control panel.

2.17 ADDITIONAL BATTERY MONITORING

A. Monitoring features and components shall include the following:

1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
2. Connections for data transmission via RS-232 link, network interface and modem and external signal wiring to a computer. External signal wiring and computer are not specified in this Section.
3. Software designed to store and analyze battery data using an IBM-compatible computer that is not specified in this Section. Software reports individual-cell parameters and total battery performance trends and provides data for scheduling and prioritizing battery maintenance.

B. Functional Performance: Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events record measurements timed to the nearest second. Include measurements of the following parameters:

1. Total battery voltage and ambient temperature.
2. Individual-cell voltage, impedance, and temperature. Measure battery and cell voltages and time to the nearest second during battery-discharging events such as utility outages.
3. Individual-cell electrolyte levels.

2.18 BATTERY CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by a cycle-life warranty.

B. Basic Functional Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminals, providing alarm for excursions outside the proper float voltage level.
2. Monitors: Ambient temperature at battery and initiates an alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to provide local remote alarm for battery discharge events abnormal temperature abnormal battery voltage or temperature.
5. Memory: Device stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading data to a portable personal computer.
7. Modem: Makes measurements and recorded data accessible to remote personal computer via telephone line. Computer is not specified in this Section.

2.19 SOURCE QUALITY CONTROL

A. Factory test complete UPS, including battery, before shipment. Include the following tests:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.
6. Efficiency test at 50, 75, and 100 percent of rated full-load current at rated power factor.

B. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's option.

C. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install system components on 4-inch- (100-mm-) high concrete bases. Cast-in-place concrete, reinforcing, and formwork are specified in Division 3.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.

3.2 GROUNDING

A. Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" for materials and installation requirements.

B. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

3.3 IDENTIFICATION

A. Identify components and wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify each battery cell individually.

3.4 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage the services of a factory-authorized service representative to supervise UPS installation, startup, and preliminary testing and adjustment and to participate in final tests, inspections, and adjustments.

B. Electrical Tests and Inspections: Perform tests and inspections according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each component of the UPS:

1. Inspect interiors of enclosures, including the following:

    a. Integrity of mechanical and electrical connections.
    b. Component type and labeling verification.
    c. Ratings of installed components.

2. Test manual and automatic operational features and system protective and alarm functions.
3. Test communication of status and alarms to remote monitoring equipment.

C. Electrical Tests and Inspections: Perform tests and inspections listed below according to manufacturer's written instructions and as listed below to demonstrate condition and performance of each UPS:

1. Inspect interiors of enclosures, including the following:

    a. Integrity of mechanical and electrical connections.
    b. Component type and labeling verification.
    c. Ratings of installed components.

2. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the unit's rating. Use instruments calibrated, within the previous six months according to NIST standards.

    a. Simulate malfunctions to verify protective device operation.
    b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    c. Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
    d. Test output voltage under specified transient-load conditions.
    e. Test efficiency at 50, 75, and 100 percent rated loads.
    f. Test remote status and alarm panel functions.
    g. Test battery-monitoring system functions.

D. Seismic-restraint tests and inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
2. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Retest: Correct deficiencies and retest until specified requirements are met.

F. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.7 FUNCTIONAL PERFORMANCE TESTING

A. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.

1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
2. Schedule monitoring and testing after Substantial Completion, when UPS is supplying power to its intended load.

B. Monitoring and Testing Instruments: Three-phase, recording power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at input terminals of the UPS and at input terminals of a load served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

1. Current: Each phase and neutral and grounding conductors.
2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
3. Frequency transients.
4. Voltage swells and sags.

5. Voltage impulses, phase to phase, phase to neutral, phase to ground, and neutral to ground.
6. High-frequency noise.
7. Radio-frequency interference.
8. THD of the above currents and voltages.
9. Harmonic content of currents and voltages above.

C. Monitoring and Testing Procedure: As follows for each test period:

1. Exploratory Period: For approximately the first two days, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these preliminary measurements with the objective of identifying optimum UPS, power system, load, and instrumentation set-up conditions for subsequent test and monitoring operations.
2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.

    a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS with respect to values specified in Part 2 of this Section, and to highlight any need to adjust, repair, or modify the UPS or any distribution system or load component that may influence its performance or that may require better power quality.
    b. Perform load and UPS power source switching and operate the UPS on generator power during portions of the test period according to directions of Owner's Power Quality Consultant.
    c. Operate the UPS and UPS loads in each mode of operation permitted by UPS controls and by the power distribution system design.
    d. Create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients using temporarily connected resistive/inductive load banks. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    e. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

D. Correlation with Specified UPS Monitoring Functions: Obtain printout recordings of built-in monitoring functions specified for UPS and UPS components in this Section that are simultaneous with those made with portable instruments in this Article.

1. Provide the temporary use of an appropriate personal computer and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Correlate printouts with recordings for monitoring performed according to this Article, and resolve and report any anomalies in and discrepancies between the two sets of records.

E. Monitoring and Testing Assistance by Contractor: As follows:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.

2. Observe monitoring and testing operations and ensure UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by Power Quality Consultant. The consultant shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of UPS manufacturer's factory-authorized service representative periodically through functional performance testing operations for repairs, adjustments, and consultations.

F. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Correlate simultaneous recordings made on UPS input and load circuits.

G. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in final report:

1. Description of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendation for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, or their connections or controls.

H. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of the final test and analysis period.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 263353

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switch.

1.3 SUBMITTALS

A. Product Data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.

C. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer.

D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.

G. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing emergency maintenance and repairs at Project site with an eight-hour maximum response time.

B. Source Limitations: Obtain automatic transfer switch from a single manufacturer or as specified.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction.

D. Comply with NEMA ICS 1.

E. Comply with NFPA 70.

F. Comply with NFPA 99.

G. Comply with NFPA 110.

H. Comply with UL 1008, unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Conventional Transfer Switches:

a. Caterpillar, Inc.; Engine Division.
b. Onan Corp.; Electrical Products Division.
c. Generac
d. Detroit Diesel
e. Kohler

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where Transfer Switch Includes Internal Fault-Current Protection: Rating of switch and trip unit combination exceeds indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

F. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral are double nominal rating of circuit in which switch is installed.

G. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6; UL 508, unless otherwise indicated.

H. Factory Wiring: Train and bundle factory wiring and label consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

J. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units rated 225 A and greater have separate arcing contacts.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is the same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Signal-before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

F. Digital Communications Interface: Matched to capability of remote annunciator or annunciator and control panel. The transfer switch shall be provided with a network communication card, and configured to allow LON MARK compliant communication with the transfer switch and other network system component.

2.4 AUTOMATIC TRANSFER-SWITCH FEATURES

A. Under voltage sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator set. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes; factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained under voltage of emergency source, provided normal supply has been restored.

E. Test Switch: Simulates normal-source failure.

F. Switch-Position Pilot Lights: Indicate source to which load is connected.

G. Source-Available Indicating Lights: Supervise sources via transfer-switch, normal- and emergency-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

H. Unassigned Auxiliary Contacts: Two normally open single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

I. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

J. Engine Starting Contacts: One isolated, normally closed and one isolated, normally open, rated 10 A at 32-V dc minimum.

K. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes; factory set for five minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.

2.5 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

A. Factory Test Components, Assembled Switches, and Associated Equipment: Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 APPLICATION

A. Four-Pole Switches: install neutral switching.

3.2 INSTALLATION

A. Wall-Mounted Switch: Level and secure unit to wall.

B. Identify components according to Division 26 Section "Common Work Results For Electrical."

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

3.3 WIRING TO REMOTE COMPONENTS

A. Match type and number of cables and conductors to control and communications requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.4 CONNECTIONS

A. Ground equipment as indicated and as required by NFPA 70.

3.5 FIELD QUALITY CONTROL

A. Testing: Test transfer-switch products by operating them in all modes. Perform tests recommended by manufacturer under the supervision of manufacturer's factory-authorized service representative. Correct deficiencies and report results in writing. Record adjustable relay settings.

B. Testing: Perform the following field quality-control testing under the supervision of the manufacturer's factory-authorized service representative in addition to tests recommended by the manufacturer:

1. Before energizing equipment, after transfer-switch products have been installed:

    a. Measure insulation resistance phase-to phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.
    b. Check for electrical continuity of circuits and for short circuits.
    c. Inspect for physical damage; proper installation and connection; and integrity of barriers, covers, and safety features.
    d. Verify that manual transfer warnings are properly placed.
    e. Perform manual transfer operation.

2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test automatic transfer-switch operations.
    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown sequence.

C. Coordinate tests with tests of generator plant and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:

1. Coordinate this training with that for generator equipment.

2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
6. Provide a minimum of four hours of instruction.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes lightning protection.

1.3 SUBMITTALS

A. Product Data: For air terminals and mounting accessories.

B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway and data on how concealment requirements will be met.

C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by nationally recognized testing laboratory (NRTL) or trade association.

D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

E. Field inspection reports indicating compliance with specified requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is NRTL listed or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, Article 2-2, "Definitions."

C. Provide UL Master Label.

D. Provide LPI certification of system.

E. Provide ETL Master Label indicating system complies with specified requirements.

1.5 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to single-membrane roof systems with roofing manufacturer and installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A-C Lightning Security, Inc.
2. Automatic Lightning Protection.
3. Harger Lightning Protection, Inc.
4. Heary Bros. Lightning Protection Co. Inc.
5. Independent Protection Company, Inc.
6. Robbins Lightning, Incorporated.
7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.

B. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and standards referenced in this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

B. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view from exterior locations at grade within 200 feet of building.

5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

C. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

D. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

E. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

F. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.

1. Bond ground terminals to counterpoise conductor.
2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.

G. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

A. Periodic Inspections: Engage an LPI inspector to perform periodic inspections during construction and at its completion, according to LPI-177.

B. UL Inspection: Apply for inspection by UL as required to obtain a UL Master Label for system.

C. ETL Inspection: Engage an ETL inspector to inspect completed system for compliance with specified requirements.

3.4 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 264113

SECTION 264313 - TRANSIENT VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transient voltage surge suppressors for low-voltage power, control, and communication equipment.

B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for devices with integral transient voltage surge suppressors.
2. Division 26 Section "Panelboards" for factory-installed transient voltage surge suppressors.
3. Division 26 Section "Switchboards" for factory-installed transient voltage surge suppressors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Product Certificates: Signed by manufacturers of transient voltage suppression devices, certifying that products furnished comply with the following testing and labeling requirements:

1. UL 1283 certification.
2. UL 1449 listing and classification.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

D. Maintenance Data: For transient voltage suppression devices to include in maintenance manuals specified in Division 1.

E. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

B. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Other manufacturers' products complying with requirements may be considered. Refer to Division 1 Section "Substitutions."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. IEEE Compliance: Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide for Surge Suppressor Testing."

E. NEMA Compliance: Comply with NEMA LS 1, "Low Voltage Surge Protective Devices."

F. UL Compliance: Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.5 PROJECT CONDITIONS

A. Placing into Service: Do not energize or connect service entrance equipment panelboards to their sources until the surge protective devices are installed and connected.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Service Conditions: Rate surge protective devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 120 deg F.
3. Humidity: 0 to 85 percent, noncondensing.
4. Altitude: 4000 feet above sea level.

1.6 COORDINATION

A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

1.7 WARRANTY

A. General Warranty: Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of Substantial Completion.

C. Special Warranty for Plug-in Cord-Connected Surge Suppressors: Written warranty, executed by manufacturer agreeing to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Manufacturers of a Broad Line of Suppressors:
   a. Current Technology, Inc.
   b. Liebert Corp.
   c. United Power, Inc.
   d. Intermatci.
   e. LEA International.
   f. EFI.

2.2 SERVICE ENTRANCE SUPPRESSORS

A. Surge Protective Device Description: Non-modular type with the following features and accessories:

1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. One set of dry contacts rated at 5 a, 250-V ac, for remote monitoring of protection status.

B. Surge Protective Device Description: Modular design with field-replaceable modules and the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.

2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with copper busbars and for bolted connections to phase buses, neutral bus, and ground bus.
7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
8. Red and green LED indicator lights for power and protection status.
9. Audible alarm, with silencing switch, to indicate when protection has failed.
10. One set of dry contacts rated at 5 a and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
11. Surge-event operations counter.

C. Peak Single-Impulse Surge Current Rating: 320 kA per phase.

D. Connection Means: Permanently wired.

E. Protection modes and UL 1449 clamping voltage for grounded wye circuits with voltages of 480Y/277 and 208Y/120; 3-phase, 4-wire circuits, shall be as follows:

1.	Line to Neutral:	800 V for 480Y/277	400 V for 208Y/120.
2.	Line to Ground:	800 V for 480Y/277	400 V for 208Y/120.
3.	Neutral to Ground:	800 V for 480Y/277	400 V for 208Y/120.

F. Protection modes and UL 1449 clamping voltage for 208/120 V, single-phase, 3-wire circuits, shall be as follows:

1.	Line to Neutral:	400 V.
2.	Line to Ground:	400 V.
3.	Neutral to Ground:	400 V.

2.3 ENCLOSURES

A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install devices for panelboard and auxiliary panels with conductors between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Provide multipole, 40 A circuit breaker as a dedicated disconnect for the suppressor, unless otherwise indicated.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with requirements.
2. Complete startup checks according to manufacturer's written instructions.
3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.19. Certify compliance with test parameters.

B. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Verify that electrical wiring installation complies with manufacturer's installation requirements.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain surge protective devices.

1. Train Owner's maintenance personnel on procedures and schedules for maintaining suppressors.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 264313

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures with lamps and ballasts.
2. Lighting fixtures mounted on exterior building surfaces.
3. Emergency lighting units.
4. Exit signs.
5. Accessories, including fluorescent fixture dimmers and occupancy sensors .

B. Related Sections include the following:

1. Division 13 Section "Lighting Controls" for manual or programmable control systems employing low-voltage control wiring or data communication circuits.
2. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
3. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. BF: Ballast factor. Ratio of light output of a given lamp(s) operated by the subject ballast to the light output of the same lamp(s) when operated on an ANSI reference circuit.

B. CRI: Color rendering index.

C. CU: Coefficient of utilization.

D. LER: Luminaire efficiency rating, which is calculated according to NEMA LE 5. This value can be estimated from photometric data using the following formula:

1. LER is equal to the product of total rated lamp lumens times BF times luminaire efficiency, divided by input watts.

E. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture scheduled, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Fluorescent and high-intensity-discharge ballasts.
3. Air and Thermal Performance Data: For air-handling fixtures. Furnish data required in "Submittals" Article in Division 15 Section "Diffusers, Registers, and Grilles."
4. Sound Performance Data: For air-handling fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 15 Section "Diffusers, Registers and Grilles."
5. Lamps.

B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

C. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which lighting-fixture suspension systems will be attached.
3. Other items in finished ceiling, including the following:

    a. Air outlets and inlets.
    b. Speakers.
    c. Sprinklers.
    d. Access panels.
    e. Fire alarm system.

4. Perimeter moldings.

E. Samples for Verification: For interior lighting fixtures designated for sample submission in the Interior Lighting Fixture Schedule.

1. Lamps: Specified units installed.
2. Ballast: 120-V models of specified ballast types.
3. Accessories: Cords and plugs.

F. Product Certificates: For each type of ballast for dimmer-controlled fixtures, signed by product manufacturer.

G. Source quality-control test reports.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures and Operation and Maintenance Data," include the following:

1. Catalog data for each fixture. Include the diffuser, ballast, and lamps installed in that fixture.

J. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. FMG Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

D. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

E. Mockups: Provide lighting fixtures for room or module mockups. Install fixtures for mockups with power and control connections.

1. Obtain Architect's approval of fixtures for mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty for Fluorescent Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

B. Manufacturer's Special Warranty for T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in

materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Products: Subject to compliance with requirements, provide one of the products specified.
      a. Refer to Light Fixture Schedule.

2.2 FIXTURES AND COMPONENTS, GENERAL

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:

   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is scheduled.
b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

J. Electromagnetic-Interference Filters: A component of fixture assembly. Suppress conducted electromagnetic-interference as required by MIL-STD-461D. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 LIGHTING FIXTURES

A. Fixture: As shown on the fixture schedules.

1. Products: As required.
2. Voltage: Verify.
3. Mounting: As required.
4. Nominal Dimensions: As shown.
5. Lamps: As shown.
6. Ballast Types and Features: Electronic .
7. Lens: As shown.
8. External Finish: As specified.
9. Trim and Hardware: Spring-loaded door latches.
10. Special Environmental Conditions: As required.
11. Other Features: As shown.
12. Submit Sample.
13. Provide fixtures as needed for mockups.

2.4 FLUORESCENT LAMP BALLASTS

A. Description: Include the following features, unless otherwise indicated:

1. Designed for type and quantity of lamps indicated at full light output.
2. Externally fused with slow-blow type rated between 2.65 and 3.0 times the line current.
3. Refer to light fixture schedule for additional requirements.

B. Electronic ballasts for linear lamps shall include the following features, unless otherwise indicated:

1. Comply with NEMA C82.11.
2. Ballast Type: Instant start, unless otherwise indicated.
3. Programmed Start: Ballasts with two-step lamp starting to extend life of frequently started lamps.
4. Sound Rating: A.
5. Total harmonic distortion rating of less than 20 percent according to NEMA C82.11.
6. Transient Voltage Protection: IEEE C62.41, Category A.
7. Operating Frequency: 20 kHz or higher.
8. Lamp Current Crest Factor: Less than 1.7.

9. Parallel Lamp Circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.

C. Ballasts for compact lamps in recessed fixtures shall have the following features, unless otherwise indicated:

1. Type: Electronic .
2. Power Factor: 90 percent, minimum.
3. Flicker: Less than 5 percent.
4. Lamp Current Crest Factor: Less than 1.7.
5. Electronic Ballast Operating Frequency: 40 kHz or higher.
6. Lamp end-of-life detection and shutdown circuit.
7. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
8. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

D. Ballasts for Low-Temperature Environments:

1. Temperatures 0 deg F (Minus 17 deg C) and Higher: Electronic or electromagnetic type rated for 0 deg Fminus 17 deg C starting temperature.
2. Temperatures Minus 20 deg FMinus 29 deg C and Higher: Electromagnetic type designed for use with high-output lamps.

E. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.

2.5 HIGH-INTENSITY-DISCHARGE LAMP BALLASTS

A. General: Comply with NEMA C82.4 and UL 1029. Shall include the following features, unless otherwise indicated.

1. Type: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg FMinus 30 deg C for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F40 deg C.
4. Open-circuit operation that will not reduce average life.

B. Auxiliary, Instant-On, Quartz System: Automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. Automatically turns quartz lamp off when high-intensity-discharge lamp reaches approximately 60 percent light output.

C. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.

2.6 FLUORESCENT LAMPS

A. Alto lamps with green ends are not acceptable.

B. Low-Mercury Lamps: Comply with Federal toxic characteristic leaching procedure test, and yield less than 0.2 mg of mercury per liter, when tested according to NEMA LL 1.

C. T8 rapid-start low-mercury lamps, rated 32 W maximum, 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 4100 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches610 mm, 1300 initial lumens (minimum), CRI of 75 (minimum), color temperature of 4100 K, and average rated life of 20,000 hours, unless otherwise indicated.

E. Compact Fluorescent Lamps: CRI 80 (minimum), color temperature 4100, average rated life of 10,000 hours at 3 hours operation per start, unless otherwise indicated.

1. T4, Twin Tube: Rated 5 W, 250 initial lumens (minimum).
2. T4, Twin Tube: Rated 7 W, 400 initial lumens (minimum).
3. T4, Twin Tube: Rated 9 W, 600 initial lumens (minimum).
4. T4, Twin Tube: Rated 13 W, 825 initial lumens (minimum).
5. T4, Double-Twin Tube: Rated 13 W, 900 initial lumens (minimum).
6. T4, Double-Twin Tube: Rated 18 W, 1200 initial lumens (minimum).
7. T4, Double-Twin Tube: Rated 26 W, 1800 initial lumens (minimum).

2.7 HIGH-INTENSITY-DISCHARGE LAMPS

A. Metal-Halide Lamps: ANSI C78.1372, wattage and burning position as scheduled, CRI 65 (minimum), and color temperature 4000.

2.8 FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Common Work Results For Electrical " for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, 12 gage.

E. Wires For Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch- minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

H. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.9 FINISHES

A. Fixtures: Manufacturers' standard, unless otherwise indicated.

1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
2. Metallic Finish: Corrosion resistant.

2.10 LIGHTING CONTROL DEVICES

A. Dimming Ballast Controls: Sliding-handle type with on/off control; compatible with ballast and having light output and energy input over the full dimming range.

B. Light Level Sensor: Detect changes in ambient lighting level and provide dimming range of 20 to 100 percent in response to change.

1. Sensor Capacity: At least 40 electronic dimming ballasts.
2. Adjustable Ambient Detection Range: 10 to 100 fc minimum.

C. Occupancy Sensors: Adjustable sensitivity and off delay time range of 5 to 15 minutes.

1. Device Color:

a. Wall Mounted: By Architect.
b. Ceiling Mounted: White.

2. Occupancy detection indicator.
3. Ultrasonic Sensors: Crystal controlled with circuitry that causes no detection interference between adjacent sensors.
4. Infrared Sensors: With daylight filter and lens to afford coverage applicable to space to be controlled.
5. Combination Sensors: Ultrasonic and infrared sensors combined.

2.11 FLUORESCENT FIXTURE RETROFIT MATERIALS

A. Comply with UL 1598 listing requirements.

1. Reflector Kit: UL 1598, Type I. Suitable for two- to four-lamp, surface-mounted or recessed lighting fixtures by improving reflectivity of fixture surfaces. No electrical parts are to be changed.
2. Ballast and Lamp Change Kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets as scheduled.

2.12 SOURCE QUALITY CONTROL

A. Provide services of a qualified, independent testing and inspecting agency to factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

B. Factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.

1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least two independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Fixture Support: As follows:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Continuous Rows: Suspend from cable.

D. Air-Handling Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable fixtures to provide required light intensities.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Verify normal operation of each fixture after installation.

C. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal.

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

E. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

3.4 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Exterior luminaires with lamps and ballasts, but not mounted on exterior surfaces of buildings.
2. Luminaire-mounted photoelectric switches.

B. Related Sections include the following:

1. Division 2 Section "Lighting Poles and Standards" for poles and other support structures and for requirements of resistance to wind loads.
2. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 SUBMITTALS

A. Product Data: For each luminaire, arranged in the order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Luminaire dimensions, effective projected area, details of attaching luminaires, accessories, and installation and construction details.
3. Luminaire materials.
4. Photoelectric relays.
5. Fluorescent and high-intensity-discharge ballasts.
6. Fluorescent and high-intensity-discharge lamps.
7. Electrical and energy-efficiency data for ballasts.

B. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufacturer.

C. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Mounting and connection details, drawn to scale, for exterior luminaires with requirements specified in Division 2 Section "Lighting Poles and Standards."

E. Samples for Verification: For exterior luminaires designated for sample submission in the Exterior Luminaire Schedule.

1. Lamps: Specified units installed.
2. Ballast: 120-V models of specified ballast types.
3. Finishes: For each finished metal used in support components.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For luminaires to include in maintenance manuals.

I. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. FMG Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

C. Comply with IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate exterior luminaires with mounting and wind load requirements in Division 2 Section "Lighting Poles and Standards."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace luminaires or components of luminaires and lamps that fail in materials or workmanship; corrode; or fade, stain, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.

a. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
b. Warranty Period for Color Retention: Five years from date of Substantial Completion.

2. Warranty Period for Lamps: Replace lamps and fuses that fail within 12 months from date of Substantial Completion; furnish replacement lamps and fuses that fail within the second 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Products: Subject to compliance with requirements, provide one of the products specified.

2.2 LUMINAIRES, GENERAL

A. Complying with UL and listed for installation in wet locations.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

J. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

2.3 EXTERIOR LUMINAIRES

1. Refer to Light fixtures schedule.

2.4 PHOTOELECTRIC RELAYS

A. UL 773 or UL 773A listed, factory mounted to the luminaire.

B. Contact Relays: Single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.

1. Relay with locking-type receptacle shall comply with NEMA C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.5 FLUORESCENT LAMP BALLASTS

A. Ballasts shall be suitable for low-temperature environments.

1. Temperatures 0 Deg F and Higher: Electronic or electromagnetic type rated for 0 deg F starting temperature.
2. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
3. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with high-output lamps.

B. Ballasts for compact lamps shall be suitable for cold-weather starting and shall include the following:

1. Power Factor: 90 percent, minimum.
2. Ballast-Coil Temperature: 65 deg C, maximum.
3. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.

2.6 HIGH-INTENSITY-DISCHARGE LAMP BALLASTS

A. General: Comply with NEMA C82.4 and UL 1029. Shall include the following features, unless otherwise indicated:

1. Type: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F.
4. Open-circuit operation will not reduce average life.
5. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. Automatically turns quartz lamp off when high-intensity-discharge lamp reaches approximately 60 percent light output.

2.7 FLUORESCENT LAMPS

A. Compact Fluorescent Lamps: CRI 80 (minimum), color temperature 4100, averaged rated life of 10,000 hours at 3 hours operation per start, unless otherwise indicated.

1. T4, Double-Twin Tube: Rated 18 W, 1200 initial lumens (minimum).
2. T4, Double-Twin Tube: Rated 26 W, 1800 initial lumens (minimum).

2.8 HIGH-INTENSITY-DISCHARGE LAMPS

A. Metal-Halide Lamps: ANSI C78.1372, wattage and burning position as scheduled, CRI 65 (minimum), and color temperature 4000.

2.9 FACTORY FINISHES

A. Field Painting Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match process and color of pole or support materials specified in Division 2 Section "Lighting Poles and Standards."

C. Factory-Painted Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Interior Surfaces: Apply one coat of bituminous paint on interior of pole, or otherwise treat to prevent corrosion.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: Match Architect's sample of manufacturer's standard color.

D. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: As required by Architect.

4. Gold Anodic Finish: AA-M32C22A43 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, impregnated color coating 0.018 mm or thicker) complying with AAMA 611.

2.10 SOURCE QUALITY CONTROL

A. Provide services of a qualified, independent testing and inspecting agency to factory test luminaires with ballasts and lamps; certify results for isofootcandle curves, zonal lumen, average and minimum ratios, and electrical and energy-efficiency data for ballasts.

B. Factory test fixtures with ballasts and lamps; certify results for isofootcandle curves, zonal lumen, average and minimum ratios, and electrical and energy-efficiency data for ballasts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lamps in each fixture.

B. Luminaire Attachment: Fasten to indicated structural supports.

C. Adjust luminaires that require field adjustment or aiming.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

1. IESNA LM-5.
2. IESNA LM-50.
3. IESNA LM-52.
4. IESNA LM-64.
5. IESNA LM-72.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 265600

SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Communications equipment coordination and installation.
2. Sleeves for pathways and cables.
3. Sleeve seals.
4. Grout.
5. Common communications installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 QUALITY ASSURANCE

A. Telecommunications contractor shall be a Siemon Certified Installer. Approved telecommunications contractors are:

1. Cache Valley Electric
2. Federal Communications
3. Niels Fugal
4. Americom

1.6 COORDINATION

A. All work to be bid on or done at AGCW (Camp Williams) shall be closely coordinated with UTNG State Telecommunications Manager, Mike Hansen at (801) 249-3838 or Toby Adamson at (801) 241-9942, prior to beginning any work.

B. Coordinate arrangement, mounting, and support of communications equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 270500

SECTION 27 08 00
COMMISSIONING OF COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

01 08 00 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

27 05 00	Common Work Results for Communications
27 13 00	Communications Backbone Cabling
27 15 00	Communications Horizontal Cabling

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 01 08 00, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 01 08 00, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	**Responsible Contractor**	**Proposed Document Received**	**OK**	**Completed Document Received**	**OK**	**Notes**
Data Infrastructure						
Polarity, continuity & grounding/short verification						
Attenuation						
Signal to Noise Ratio						
NEXT, ELFECT, PSNEXT, ACR Testing						
Propagation Delay Tests						
Return Loss Tests						
Manufacturer Installation Documentation						
System Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.

B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.

C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.

D. Indicates that CA has received and approved proposed installation and start-up documentation.

E. Date the completed documents are received by the CA from the responsible Contractor.

F. Indicates that CA has received and approved completed documentation.

G. Notes on status of forms, irregularities and rework needed.

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System Readiness Checklist (Preliminary Version)
Data Distribution System

Installation:

All wiring, terminations, patch panels, cross-blocks have been labeled per the project requirements.

All conduit, tray, inner ducts, poles and sleeves have been labeled per the project requirements.

All cabling and hardware have been labeled per the project requirements.

All color coding standards have been met.

All station outlets have been labeled per the project requirements.

All cabling has been installed pert he manufacturer specifications.

All entrance cables with metal sheath have been grounded and bonded per the project requirements.

Maintenance loops in cables have been provided as required.

All grounding and bonding procedures completed per the project requirements.

Start-Up:

Commissioning Authority has been notified for witness of start-up.

All manufacturer-required system testing has been completed and reports submitted.

Readiness:

Manufacturer's installation and start-up procedures were followed.

As-built drawings have been updated and submitted.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
	Responsible Contractor	**Proposed Test Forms Received**	**OK**	**Testing Complete**	**OK**	**Notes**
Data Distribution						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Data and Telecommunications Systems

Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Functional Tests:

a) UTP, Fiber Cable tests per 271300 and 271500

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	**Responsible Contractor**	**Proposed Agenda Received**	**OK**	**Training Performed**	**OK**	**Closeout Form Received**	**OK**	**Notes**
Data Distribution								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. **This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor**. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

Not Used. Communications contractor to provide test report format per specified testing requirements

END OF SECTION 27 08 00

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SECTION 271300 - COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. UTP cable.
2. 62.5/125-micrometer, optical fiber cabling.
3. Cable connecting hardware, patch panels, and cross-connects.
4. Cabling identification products.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.4 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Telecommunications contractor shall be a Siemon Certified Installer. Approved telecommunications contractors are:

1. Cache Valley Electric
2. Federal Communications
3. Niels Fugal
4. Americom

B. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

F. Grounding: Comply with ANSI-J-STD-607-A.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. All work to be bid on or done at AGCW (Camp Williams) shall be closely coordinated with UTNG State Telecommunications Manager, Mike Hansen at (801) 249-3838 or Toby Adamson at (801) 241-9942, prior to beginning any work.

B. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

B. Green Backboard Metal M183 B2 (VAR)

C. Full Spool boards. M187 B1 (VAR)

2.2 MANHOLE HARDWARE

A. Copper Splice Cases 3M KB6 series. Coordinate with Mike or Toby to determine what ends need to be placed on the ends of the splice case.

B. Fiber Splice Case Coyote 80805514. Splice tray will depend on amount of fiber.

2.3 WIRE MANAGEMENT

A. Siemon S188-300 Vertical Wire Management

B. Siemon S110M-WM-300 Vertical Wire Management

2.4 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Siemon Co..

B. Description: 100-ohm UTP, quantity of pairs as shown on the drawings, formed into 25-pair binder groups covered with a gray thermoplastic jacket.

   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with TIA/EIA-568-B.1 for performance specifications.
   3. Comply with TIA/EIA-568-B.2, Category 6.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.

2.5 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Siemon Co. (The).

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: Siemon S210MB2-300 with Siemon S210C-4 connectors.

D. Patch Panel: Siemon SPB-V1 24 Port Patch Panel.

   1. Number of Jacks per Field: One for each four-pair UTP cable indicated.

2.6 LIGHTNING PROTECTION PANELS

A. Marconi R66P25QC Lighting Protection Panel.

B. Gas Protection Fuses 104410147

2.7 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Siemon Co.

B. Description: Multimode, 62.5/125-micrometer, 24-fiber, tight buffer, optical fiber cable.

   1. Comply with ICEA S-83-596 for mechanical properties.

2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

   a. General Purpose, Nonconductive: Type OFN or OFNG.

C. Jacket:

1. Jacket Color: Orange for 62.5/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.8 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Siemon Co. (The).
2. SECOR

B. Cross-Connects and Patch Panels: 11. SECOR WIC 012 LIU can.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.

2.9 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.10 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. Manholes:

1. When pulling service entrance cable from a manhole to the building, leave a 20 ft maintenance loop, and in every manhole between.
2. All splices will be sealed water tight. If a case is opened, it will be resealed to maintain a water tight seal.
3. All splices in the fiber cable will be fusion spliced.
4. Splices in the copper cable will be done in a splice case and made water tight.

C. Telecommunications Rooms: Install plywood backboards on all walls of telecommunications rooms. Layout of termination equipment in the telecommunications rooms shall be as follows:

1. From left to right the positioning of the metal backboards will be Green, Blue, and Yellow.
2. Leave proper space between the blue and yellow boards to accommodate future growth.
3. Along the bottoms of each of the backboards install full spool boards.
4. On the Green backboard install the copper service entrance cables for the building, and/or the backbone copper cables for the building. The copper feeds will be terminated to the lightning protection panel and then cross connected to the to the Siemon 24 port patch panel. .
5. On the blue and yellow backboards, horizontal cabling will be installed. See Section 271500 “Communications Horizontal Cabling” for more information.

D. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

E. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

F. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

G. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with TIA/EIA-569-A, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with requirements to be determined by owner.

B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.9 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 271300

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. UTP cabling.
2. Cable connecting hardware, patch panels, and cross-connects.
3. Telecommunications outlet/connectors.
4. Cabling system identification products.

B. Related Sections:

1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

G. RCDD: Registered Communications Distribution Designer.

H. UTP: Unshielded twisted pair.

1.4 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

B. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated.

1. For coaxial cable, include the following installation data for each type used:

a. Nominal OD.
b. Minimum bending radius.
c. Maximum pulling tension.

B. Shop Drawings:

1. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.

D. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Telecommunications contractor shall be a Siemon Certified Installer. Approved telecommunications contractors are:

1. Cache Valley Electric
2. Federal Communications

3. Niels Fugal
4. Americom

B. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
2. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Grounding: Comply with ANSI-J-STD-607-A.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.9 COORDINATION

A. All work to be bid on or done at AGCW (Camp Williams) shall be closely coordinated with UTNG State Telecommunications Manager, Mike Hansen at (801) 249-3838 or Toby Adamson at (801) 241-9942, prior to beginning any work.

PART 2 - PRODUCTS

2.1 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

B. Blue Backboards: Metal M183 B1 (VAR)

C. Yellow Backboards Metal M183 B5 (VAR)

D. Full Spool boards. M187 B1 (VAR)

2.2 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Siemon Cat 6 Blue 9C6R4-E3-06-RBN

2. Siemon Cat 6 Yellow 9C6R4-E3-05-RBN

B. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   b. Communications, Riser Rated: Type CMR, complying with UL 1666.

2.3 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Siemon Co. (The).

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Patch Panel: Siemon HD6-89D-12.

1. Number of Jacks per Field: One for each four-pair.

D. Patch Cords: Factory-made, four-pair cables in length as required; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: Siemon CT-C6-C6-02 Angled Jack. 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.

B. Workstation Outlets: Siemon CT2-FP-02 Faceplate.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices."

   a. Flush mounting jacks, positioning the cord at a 45-degree angle.

2. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.5 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.6 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF CABLES

A. Install plywood backboards on all walls of telecommunications rooms. Layout of termination equipment in the telecommunications rooms shall be as follows:

1. From left to right the positioning of the metal backboards will be Green, Blue, and Yellow.
2. Leave proper space between the blue and yellow boards to accommodate future growth.
3. Along the bottoms of each of the backboards install full spool boards.
4. On the Green backboard install the copper service entrance cables for the building, and/or the backbone copper cables for the building. See Section 211300 “COMMUNICATIONS BACKBONE CABLING” for more information.
5. On the Blue backboard, the Blue Siemon CAT 6 cables, will be terminated to the Siemon HD6-89D-12 patch panels.
6. On the Yellow backboard, the Yellow Siemon CAT 6 cables, will be terminated to the Siemon HD6-89D-12 patch panels.

7. There will be one blue and one yellow CAT 5 or CAT 6 wire pulled to telecommunications outlet. They will correlate with the same number on the patch panel (ex. Jack 101 will have one blue and one yellow wire that will be in the same location on the patch panel.)

B. Comply with NECA 1.

C. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.3 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with requirements to be determined by Owner. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention determined by Owner. Furnish electronic record of all drawings, in software and format selected by Owner.

E. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. UTP Performance Tests:

    a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:

        1) Wire map.
        2) Length (physical vs. electrical, and length requirements).
        3) Insertion loss.
        4) Near-end crosstalk (NEXT) loss.
        5) Power sum near-end crosstalk (PSNEXT) loss.
        6) Equal-level far-end crosstalk (ELFEXT).
        7) Power sum equal-level far-end crosstalk (PSELFEXT).
        8) Return loss.
        9) Propagation delay.
        10) Delay skew.

6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

    a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets. Include training in cabling administration software.

3.8 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 271500

SECTION 28 08 00
COMMISSIONING OF ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

a. System specific commissioning procedures

B. Related Sections:

a. The following sections specify commissioning activities for this project:

01 08 00 – Commissioning General Requirements

b. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

28 31 11 Digital, Addressable Fire Alarm System

1.2 DESCRIPTION OF WORK

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.1 Documentation requirements for the systems to be commissioned are specified in Section 01 08 00, Part 2 - Products

PART 3 – EXECUTION

3.1 Execution of the commissioning process for the systems to be commissioned is specified Section 01 08 00, Part 3 - Execution

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRCs may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table - A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure tests, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table - A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description / Documents Required	**Responsible Contractor**	**Proposed Document Received**	**OK**	**Completed Document Received**	**OK**	**Notes**
Fire Alarm						
Polarity, continuity & grounding verification						
Device and system point to point checks						
Manufacturer Start-up Documentation						
System Readiness Checklist		CA Provided				

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Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.

B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.

C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.

D. Indicates that CA has received and approved proposed installation and start-up documentation.

E. Date the completed documents are received by the CA from the responsible Contractor.

F. Indicates that CA has received and approved completed documentation.

G. Notes on status of forms, irregularities and rework needed.

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System Readiness Checklist (Preliminary Version)
Fire Alarm System

Installation:

All wiring, terminations, patch panels, cross-blocks have been labeled per the project requirements.

All wiring installed in conduit per the project requirements.

All devices installed and adjusted for proper operation.

Maintenance free batteries provided and sized to provide required system back-up and alarm functions.

System is configured for connection to dispatch as required.

All programming and system configuration complete.

Control panel is properly grounded.

All fusing has been installed as required.

All grounding and bonding procedures completed per the project requirements.

Start-Up:

Commissioning Authority has been notified for witness of start-up.

Polarity, continuity and grounding verification.

System point to point testing complete and reports submitted.

Readiness:

Manufacturer's installation and start-up procedures were followed.

Damaged factory finishes have been replaced, repaired or touched up.

Equipment and systems are labeled per project documents.

Equipment not painted at factory has been painted with a finish coat of paint (no primer).

All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

Note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

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SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1 The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2 The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3 Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. If systems fail the initial tests additional testing may be required.

4 The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5 The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of 5 working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6 The "Responsible Contractor" column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

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Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
	Responsible Contractor	**Proposed Test Forms Received**	**OK**	**Testing Complete**	**OK**	**Notes**
Fire Alarm						

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing testing. To be filled in after contract award.
C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).
D. Indicates that CA has received and approved the proposed test forms.
E. Date(s) testing was performed by contractor.
F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.
G. Notes on status of forms, irregularities and rework needed.

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Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.
3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA during testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.
2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

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Fire Alarm System
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
A.1	Contractor	Contractor	N/A	100%

Note: These tests to take place prior to demonstration to Authority Having Jurisdiction

Functional Tests:

1) Wiring
   a) Grounding resistance
   b) Absence of voltage.
   c) Polarity
   d) Short circuits.
   e) Circuit resistance.

2) System Tests
   a) FAP Feature demonstration.
   b) Input device reporting
   c) Output device operation and reporting
   d) FAP System Trouble.
   e) Initiating and indicating circuit and device trouble alarms
   f) Dial up
   g) Secondary power operation.
   h) Battery capacity
   i) Reporting interface point-to-point and mapping
   j) Audible levels, strobe levels

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SCHEDULE C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet.
2. Required training hours specified in the project documents.
3. Detailed list of subject to be covered and durations.
4. Qualifications of training provider.
5. Training schedule including duration of each training session.

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Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	**Responsible Contractor**	**Proposed Agenda Received**	**OK**	**Training Performed**	**OK**	**Closeout Form Received**	**OK**	**Notes**
Fire Alarm								

Summary Table Key:

A. System description for each system commissioned.
B. Contractor responsible for providing project closeout and training. To be filled in after contract award.
C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor.
D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda.
E. Date the training was performed and witnessed by the Commissioning Coordinator
F. Indicates that Commissioning Coordinator has witnessed and approved the training provided.
G. Date the completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor.
H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists.
I. Notes on status of forms, irregularities and rework needed.

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Contractor Closeout Checklist (preliminary version)
System: _____

Instructions:
Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

Owner instruction is complete per project documents.

Warranty and Spares:

Warranty has been provided with operations and maintenance manuals.

All spares have been submitted to owner and receipt of materials signed.

Documentation:

O&M Manuals are complete and submitted.

As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M manuals.

Final Acceptance:

Final performance testing completed and system accepted by owner, CC and CA.

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
General Contractor CC:			

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Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1 Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.
SECTION 2 Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.
SECTION 3 The contractor responsible for training fill in this section and return to the project owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

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SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate covered items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
System/equipment troubleshooting methods, procedures, error messages as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provided and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

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SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals.	
Use of as-built drawings, plans and/or schematics.	
Discussion/lecture.	
Site demonstration of equipment operation.	
Written handouts.	
Manufacturer training manuals.	
Video presentation.	
Question and answer session.	
Training session to be taped for owner's future reference and training requirements.	

Use blank spaces to fill in any additional/other methods to be used.

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Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

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PART 4 - Sample Documents

4.1 Sample functional test procedures and data forms are provided in this section to demonstrate the rigor of the process, test procedures and documentation that will be required from the contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. **This sample section does not contain all functional test procedures and data forms that are required to be executed by the contractor**. Schedule - B of Part 3 provides a full list of the functional tests that will be required to be executed by the contractor.

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Sample Draft Functional Performance Test
Fire Alarm Wiring Continuity, Polarity and Grounding Static Tests

1. Prior to connecting any devices the wiring system is to be verified.
2. Record Zone or Circuit Number for each unique zone/circuit
3. Verify circuit continuity, polarity and grounding

Criteria: A – Continuity, B - Polarity, C - Grounding

Zone/ Circuit	Description	A	B	C	Comment

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Fire Alarm Functional Performance Testing

Functional Performance Test Summary Table:

Test No.	Test Name	Status
FA-1	FAP Feature Demonstration	
FA-2	FA Input Device Reporting	
FA-3	FA Output Device Operation	
FA-4	Fire Alarm/Trouble Reporting	
FA-5	Phone Line Monitoring	
FA-6	Initiation Circuit and Device Trouble	
FA-7	Battery Operation	

Preparation:

1. Using the field drawings, identify each fire alarm input and output device with a unique number.
2. Enter all devices into the fire alarm input and output device data sheets. Use the provided key for labeling and identifying.
3. Perform these tests while the building is generally unoccupied with one operator at the fire alarm control panel and one in at the fire alarm input devices.
4. Notify alarm monitoring company that a fire alarm test will be conducted.

Fire Alarm System Labeling Key

Abr.	Input Device	Abr.	Output Device
PS	Pull Station	H	Horn
SD	Smoke Detector	S	Strobe
DD	Duct Detector	HS	Horn/Strobe
HD	Heat Detector	MH	Magnetic Holder
FF	Fire Flow (sprinkler)	B	Bell
FT	Fire Tamper (sprinkler)	AUX	Auxiliary (HVAC tie in, etc.)
FS	Fire Suppression (kit. hood etc.)	FD	Fire and smoke dampers
		D	Dialer to monitoring

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Sample Draft Functional Performance Test
Test FA-1: Fire Alarm Feature Demonstration

Systems to be Tested:

1. Fire alarm panel

Test Objective and Success Criteria:

1. Verify all features and functions have been provided or programmed per project documents.

Preparation:

1. All start-up activities, static testing, calibration is complete

Equipment:

1. Accurate watch or clock.

Procedures:

1. Demonstrate that all features and functions are included and programmed correctly.

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Functional Performance Test Data Sheet
Test FA-1: Feature Demonstration

Test Date: ☐ **Test Time:** ☐

Test	OK	Comment
Sensitivity testing - display and print sensor sensitivity		
Automatic monthly sensitivity report - demonstrate setup and printout		
Cleaning required report - demonstrate cleaning report, adjust sensitivity thresholds if necessary.		
Sensitivity scheduling - demonstrate scheduling capability		
Day light savings adjust - demonstrate feature		
Leap year adjust - demonstrate feature		
History logging		
Battery charger mode displayed at panel		
Walk test mode		

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-2: Fire Alarm Input Device Reporting

Systems to be Tested:

1. All fire alarm input devices including, but not limited to:
    a. Smoke detectors
    b. Duct smoke detectors
    c. Heat detectors
    d. Manual pull stations
    e. Fire sprinkler flow
    f. Fire sprinkler tamper switches
    g. Fire suppression system activation

Test Objective and Success Criteria:

1. Verify all input devices activate the appropriate alarm/trouble signal.
2. Verify all devices report the correct zone, device and address at the fire alarm panel display, printer and monitoring company/system.

Preparation:

1. All start-up activities, static testing, calibration is complete.
2. Input/output devices identified on plans.

Equipment:

1. Magnet
2. Artificial smoke

Procedures:

1. One at time, activate the individual fire alarm input device by simulating an alarm condition for the type of device.
2. For smoke detectors use magnet to trip alarm if so equipped, otherwise use canned smoke.
3. For heat detectors, use magnet to trip alarm if so equipped, otherwise use heat lamp.
4. For tamper switches, close valve partially to create alarm, do not manipulate switch. To clear, open valve all the way.
5. For deluge or purge suppression systems, the system typically cannot be tripped without damaging systems and equipment. Use that systems test mode to simulate alarm.
6. Verify the system goes into fire/trouble alarm and annunciates the appropriate message at the panel and at the printer, record message and data in the Fire Alarm Input Device Test Form. If printout is available, it may be marked up and used instead of the data form.
7. If the fire alarm system is capable and configured to communicate specific data for the zone or sensor in alarm, the Fire Alarm Input Device Form is to be completed for both the local alarm reporting and for the monitoring company/system.
8. Reset the fire alarm and verify the fire alarm clears. Record data.
9. Repeat for all devices.

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Functional Performance Test Data Sheet
Test FA-2: Fire Alarm Input Device Reporting

Test Date: ☐ **Test Time:** ☐

Dwg #	Loc	Type	Address	Zone Description	A	Annunciation Displayed	C	Comment

A=Alarm Received C=Alarm Cleared

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-3: Fire Alarm Output Device Operation

Systems to be Tested:

1. All fire alarm output devices including, but not limited to:
    a. Horns & bells
    b. Strobes
    c. Magnetic door releases
    d. Autodialer/communications
    e. Auxiliary outputs (HVAC, etc.)
    f. Motorized fire/smoke dampers

Test Objective and Success Criteria:

1. Verify all output devices activate per design; horns/bells sound, strobes flash, doors release, HVAC shuts down, dampers close.
2. Verify all horn/bell audible levels meet specified output in db per project documents.
3. Verify all strobe lighting levels meet specified output in lumens per project documents.
4. Verify all output devices activate within the required time period per project documents.

Preparation:

1. All start-up activities, static testing, calibration is complete.
2. Input/output devices identified on plans.
3. Access to HVAC control system.

Equipment:

1. Sound meter
2. Light meter
3. Time keeping device

Procedures:

1. Activate fire alarm.
2. Verify all output devices operate per design (horns/bells sound, strobes flash, magnetic doors release, fire/smoke dampers close, auxiliary relays close), record test information on the Fire Alarm Output Device Test form.
3. Measure performance parameters for output devices as required by project documents (horn sound level in db, strobe light level, activation times). Record data on Fire Alarm Output Device Test Form.
4. Silence and reset fire alarm.

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Functional Performance Test Data Sheet
Test FA-3: Fire Alarm Output Device Operation

A=Activated or Annunciated - Horn, Bell, Strobe, Magnetic Hold, etc.
P=Printed - Alarm printed out.
MP= Measured Performance - db for audible, lumens for strobes, etc.

Test Date: ☐ **Test Time:** ☐

Dwg #	Loc	Type	Address	Zone Description	A	P	MP	Comment

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-4: Fire Alarm/Trouble Reporting

Systems to be Tested:

1. All fire alarm panels

Test Objective and Success Criteria:

1. Verify all alarm/trouble/supervisory signals the system is capable and configured for report to the fire alarm panel and the alarm monitoring company/system.

Preparation:

1. All start-up activities, static testing, calibration is complete.
2. Alarm monitoring company/system notified of tests.

Equipment:

1. Time keeping device.

Procedures:

1. Synchronize time keeping with alarm monitoring company/system.
2. For each type of alarm reporting the system is capable and configured for (fire alarm, supervisory, trouble, AC failure etc.) simulate an alarm or trouble condition, record time alarm/trouble was activated. If Test FA-2 included individual zone reporting to monitoring company/system then only supervisor and trouble alarms need to be tested here. Note: There are separate functional tests FA-5 & FA-6 that test phone line failure and initiation circuit failures, these can be conducted at the same time.
3. Verify panel reports alarm/trouble and buzzer sounds.
4. Verify the alarm monitoring company/system receives the alarm/trouble within the specified time.
5. Clear alarm/trouble.
6. Verify alarm monitoring company/system receives the clear signal.

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Functional Performance Test Data Sheet
Test FA-4: Fire Alarm/Trouble Reporting

Test Date: ☐ **Test Time:** ☐

Alarm/Trouble	Time Activated	Time Received	OK	Clear OK	Comment
General Fire					
Supervisory					
Trouble					
AC failure					
Phone line					
Initiation circuit					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-5: Phone Line Monitoring

Systems to be Tested:

1. All fire alarm panels.

Test Objective and Success Criteria:

1. Verify secondary line picks up on primary line failure and reports to the fire alarm panel monitoring company/system.
2. Verify secondary line failure reports to the fire alarm panel and the monitoring company/system

Preparation:

1. All start-up activities, static testing, calibration is complete.

Equipment:

1. None.

Procedures:

1. Verify all systems are normal.
2. Disconnect the secondary phone line
3. Verify trouble condition reports at panel, buzzer sounds and trouble is reported to the alarm monitoring company/system.
4. Reconnect secondary phone line.
5. Verify trouble alarm clears, silence buzzer.
6. Repeat steps 2-5 for primary phone line.

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Functional Performance Test Data Sheet
Test FA-5: Phone Line Monitoring

Test Date: ☐ **Test Time:** ☐

Phone Line Failed	Time Activated	Time Received	OK	Clear OK	Comment
Secondary					
Primary					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-6: Initiating Circuit and Device Trouble Test

Systems to be Tested:

1. All fire alarm panels and initiating circuits.

Test Objective and Success Criteria:

1. Verify all initiating circuits report a trouble conditions for all specified failure modes, including, but not limited to:

Preparation:

1. All start-up activities, static testing, calibration is complete.

Equipment:

1. Jumper wires
2. Hand tools

Procedures:

1. Conduct the following tests for each unique initiating circuits. For each test, verify that the trouble is received and correctly reported at the fire alarm panel. If the system is capable and configured to report the specific alarm to the monitoring company/system, then the form is to be completed for both the FAP and the monitoring system.
2. Create a ground fault.
3. Create a short circuit.
4. Create an open circuit.
5. Remove a device.
6. Address two devices the same.

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Functional Performance Test Data Sheet
Test FA-6: Initiating Circuit and Device Trouble

Test Date: ☐ **Test Time:** ☐

Circuit #:

Circuit/Device Trouble	A	Annunciation Displayed	C	Comment
Ground Fault				
Short Circuit				
Open Circuit				
Missing Device				
Duplicate Address				

Circuit #:

Circuit/Device Trouble	A	Annunciation Displayed	C	Comment
Ground Fault				
Short Circuit				
Open Circuit				
Missing Device				
Duplicate Address				

Circuit #:

Circuit/Device Trouble	A	Annunciation Displayed	C	Comment
Ground Fault				
Short Circuit				
Open Circuit				
Missing Device				
Duplicate Address				

A=Alarm Received C=Alarm Cleared

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

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Sample Draft Functional Performance Test
Test FA-7: Battery Operation

Systems to be Tested:

1. All fire alarm panels and associated battery systems

Test Objective and Success Criteria:

1. Verify fire alarm system can operate on back-up battery power after an AC power failure for the specified time period.
2. Verify trickle charge system is functional.

Preparation:

1. All start-up activities, static testing, calibration is complete.

Equipment:

1. Time keeping device.

Procedures:

1. Perform test with building unoccupied or with a fire watch.
2. Conduct the test when batteries have been fully charged.
3. Record battery charger status from display (volts/amps).
4. Disconnect AC power to fire panel.
5. Verify panel goes into trouble, buzzer sounds.
6. Silence panel alarm.
7. Allow fire alarm system to run for the specified length of time in supervisory mode.
8. At the end of the supervisory mode period, set off fire alarm, do not silence.
9. Verify fire alarm activates and all output devices operate for the specified period of time.
10. Clear alarms, reset panel
11. Reinstate AC power and immediately record battery charger status from display.
12. Wait the specified charge period then record battery charger status from display. Verify trickle charge is operational by noting a decrease in charging current.

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Functional Performance Test Data Sheet
Test FA-7: Battery Operation

Test Date: ☐ **Test Time:** ☐

24 Hrs	Duration for operation on batteries in supervisory mode.
5 Min	Duration for operation on batteries in alarm mode.
	Duration for battery charge test.

Battery charger volts/amps prior to test	
Date/Time of AC power failure	
Panel in AC trouble, buzzer silenced	
Date/Time of fire alarm	
Time fire alarm cleared	
All output devices operated for specified period	
Time AC power restored	
Battery charger volts/amps	
All systems normal	
Date/Time battery status checked after charging	
Battery charger volts/amps	
Trickle charge OK	

☐ Fire alarm reset and normal.
☐ Notify alarm monitoring company that all testing is complete.
☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

END OF SECTION 28 08 00

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SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Nonsystem smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Firefighters' two-way telephone communication service.
8. Magnetic door holders.
9. Remote annunciator.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.
13. System printer.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

B. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified fire-alarm technician, Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

I. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Architect's Owner's written permission.

1.9 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. SimplexGrinnell LP; a Tyco International company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Flame detectors.
4. Smoke detectors.
5. Duct smoke detectors.
6. Verified automatic alarm operation of smoke detectors.
7. Automatic sprinkler system water flow.
8. Heat detectors in elevator shaft and pit.
9. Fire-extinguishing system operation.
10. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.

7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Recall elevators to primary or alternate recall floors.
12. Activate emergency lighting control.
13. Record events in the system memory.
14. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Elevator shunt-trip supervision.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.

a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable initiation devices that communicate device identity and status.

a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.

a. Initiating Device Circuits: Style D.
b. Notification Appliance Circuits: Style Z.
c. Signaling Line Circuits: Style 2.
d. Install no more than 75 addressable devices on each signaling line circuit.

2. Serial Interfaces: Two RS-232 ports for printers.

D. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.

a. Elevator lobby detectors except the lobby detector on the designated floor.
b. Smoke detector in elevator machine room.
c. Smoke detectors in elevator hoistway.

2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

E. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

F. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

G. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and

time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

I. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

J. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.

4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Adapter plate for outlet box mounting.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.

1. Mounting: Adapter plate for outlet box mounting.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

D. Continuous Linear Heat-Detector System:

1. Detector Cable: Rated detection temperature 155 deg F. NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short- circuit wires at the location of elevated temperature.
2. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
3. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level

of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output:
   a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

D. Voice/Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Mounting: semirecessed or surface mounted and bidirectional.
4. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Surface cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

2.13 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches above the finished floor. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete and Miscellaneous Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
7. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, shall be determined according to Appendix Ain NFPA 72.
5. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

F. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

G. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

K. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

L. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated air-conditioning duct systems.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

9. Supervisory connections at elevator shunt trip breaker.
10. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
11. Supervisory connections at fire-pump engine control panel.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction and Owner representative.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
    b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm

Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

a. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

3.7 COMMISIONING

A. The equipment and systems referenced in this section are to be commissioned per Section 010800 – Commissioning General Requirements and Section 260800 – Commissioning Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, start-up, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 283111

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Protecting existing trees, shrubs, groundcovers, plants, and grass to remain.
2. Removing existing trees, shrubs, groundcovers, plants, and grass.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting and capping or sealing site utilities.
7. Temporary erosion and sedimentation control measures.

1.2 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to sediment and erosion control Drawings.

B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

3.4 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Removal of underground utilities is included in Division 22 and Division 26 Sections covering site utilities.

3.5 CLEARING AND GRUBBING

A. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

3.8 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

1. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Preparing subgrades for slabs-on-grade, walks, pavements, lawns and grasses, and exterior plants.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for slabs-on-grade.
4. Subbase course for concrete walks and pavements.
5. Subbase and base course for asphalt paving.
6. Excavating and backfilling for utility trenches.

1.2 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: AASHTO M 145 Soil Classification Groups A-1, A-2-4, A-2-5, and A-3, or a combination of these groups; free of rock or gravel larger than **3 inches** in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

2.2 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."

C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing." during earthwork operations.

3.2 EXCAVATION

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.4 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.5 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material, 4 inches deeper elsewhere, to allow for bedding course.

3.6 SUBGRADE INSPECTION

A. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Architect.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."

D. Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Place and compact final backfill of satisfactory soil to final subgrade elevation.

G. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

3.11 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
3. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.13 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.14 SUBBASE AND BASE COURSES

A. Place subbase course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course under pavements and walks as follows:

1. Shape subbase course to required crown elevations and cross-slope grades.
2. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.15 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.16 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 312000

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing hot-mix asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt paving overlay.
5. Pavement-marking paint.

B. Related Sections:

1. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
2. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants and fillers at paving terminations.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
2. Job-Mix Designs: For each job mix proposed for the Work.

B. Material Certificates: For each paving material, from manufacturer.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of APWA Manual of Standard Specifications, 2002 edition for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

C. Preinstallation Conference: Conduct conference at Project site.

1.4 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60 deg F.
2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials or 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

B. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

C. Mineral Filler: ASTM D 242, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22.

B. Tack Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

B. Pavement-Marking Paint: MPI #32 Alkyd Traffic Marking Paint.

1. Color: As indicated.

C. Pavement-Marking Paint: MPI #97 Latex Traffic Marking Paint.

1. Color: As indicated.

D. Glass Beads: AASHTO M 247, Type 1.

E. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 4-1/2 inches high by 9 inches wide by 72 inches long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: ¾”.
3. Surface Course: ½”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Spread mix at minimum temperature of 250 deg F.
2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F.

1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.8 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch .
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.9 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

1. Broadcast glass beads uniformly into wet pavement markings at a rate of 6 lb/gal..

3.10 WHEEL STOPS

A. Install wheel stops in bed of adhesive as recommended by manufacturer.

B. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Replace and compact hot-mix asphalt where core tests were taken.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.12 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes exterior cement concrete pavement for the following:

1. Driveways and roadways.
2. Parking lots.
3. Curbs and gutters.
4. Walkways.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Design Mixtures: For each concrete pavement mixture.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

D. Plain Steel Wire: ASTM A 82, as drawn.

E. Deformed-Steel Wire: ASTM A 496.

F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice."

2.2 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type II.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source.

C. Water: ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: ASTM C 494/C 494M, of type suitable for application, certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

2.3 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

2.4 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

C. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

D. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than [**3**] [**45**] minutes.

1. Color: As indicated.

2.5 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete.

1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.6 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, with the following properties:

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch.
4. Air Content: 5-1/2 percent plus or minus 1.5 percent.

B. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions.

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Proof-roll prepared subbase surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness.

E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed pavement surfaces with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on pavement surface according to manufacturer's written instructions.

1. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
2. After curing, lightly work surface with a steel wire brush or abrasive stone and water to expose nonslip aggregate.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing moisture-retaining-cover curing curing compound or a combination of these methods.

3.8 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/4 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.
6. Joint Width: Plus 1/8 inch, no minus.

3.9 PAVEMENT MARKING

A. Allow concrete pavement to cure for 28 days and be dry before starting pavement marking.

B. Sweep and clean surface to eliminate loose material and dust.

C. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 WHEEL STOPS

A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded in holes drilled or cast into wheel stops at one-quarter to one-third points. Firmly bond each dowel to wheel stop and to pavement. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.

B. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement.

C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 321373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Expansion and contraction joints within cement concrete pavement.
2. Joints between cement concrete and asphalt pavement.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For each type and color of joint sealant required.

C. Product certificates.

D. Compatibility and Adhesion Test Reports: From sealant manufacturer.

1.3 QUALITY ASSURANCE

A. Preconstruction Compatibility and Adhesion Testing: Submit samples of materials that will contact or affect joint sealants to joint-sealant manufacturers for testing according to manufacturer's standard test method to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

B. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.

2.2 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and

application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

1. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.3 COLD-APPLIED JOINT SEALANTS

A. Multicomponent Jet-Fuel-Resistant Sealant for Concrete: Pourable, chemically curing elastomeric formulation complying with the following requirements for formulation and with ASTM C 920 for type, grade, class, and uses indicated:

1. Urethane Formulation: Type M; Grade P; Class 12-1/2; Uses T, M, and, as applicable to joint substrates indicated, O.

a. Products:

1) Pecora Corporation; Urexpan NR-300.
2) As approved by engineer.

B. Single-Component Jet-Fuel-Resistant Urethane Sealant for Concrete: Single-component, pourable, coal-tar-modified, urethane formulation complying with ASTM C 920 for Type S; Grade P; Class 25; Uses T, M, and, as applicable to joint substrates indicated, O.

1. Products:

a. Sonneborn, Div. of ChemRex, Inc.; Sonomeric 1.
b. As approved by engineer.

C. Multicomponent Low-Modulus Sealant for Concrete and Asphalt: Proprietary formulation consisting of reactive petropolymer and activator components producing a pourable, self-leveling sealant.

1. Products:

a. Meadows, W. R., Inc.; Sof-Seal.
b. As approved by engineer.

2.4 HOT-APPLIED JOINT SEALANTS

A. Jet-Fuel-Resistant Elastomeric Sealant for Concrete: Single-component formulation complying with ASTM D 3569.

1. Products:

a. Crafco Inc.; Superseal 444/777.
b. Meadows, W. R., Inc.; Poly-Jet 3569.

c. As approved by engineer.

B. Jet-Fuel-Resistant Sealant for Concrete and Tar Concrete: Single-component formulation complying with ASTM D 3581.

1. Products:

a. Crafco Inc.; Superseal 1614A.
b. Meadows, W. R., Inc.; Poly-Jet 1614.
c. Meadows, W. R., Inc.; Poly-Jet 3406.
d. Meadows, W. R., Inc.; Poly-Jet 3569.
e. As approved by engineer.

C. Elastomeric Sealant for Concrete: Single-component formulation complying with ASTM D 3406.

1. Products:

a. Crafco Inc.; Superseal 444/777.
b. Meadows, W. R., Inc.; Poly-Jet 3406.
c. As approved by engineer.

D. Sealant for Concrete and Asphalt: Single-component formulation complying with ASTM D 3405.

1. Products:

a. Koch Materials Company; Product No. 9005.
b. Koch Materials Company; Product No. 9030.
c. Meadows, W. R., Inc.; Sealtight Hi-Spec.
d. As approved by engineer.

2.5 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Backer Strips for Cold- and Hot-Applied Sealants: ASTM D 5249; Type 2; of thickness and width required to control sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

D. Round Backer Rods for Cold-Applied Sealants: ASTM D 5249, Type 3, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience.

C. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

D. Install backer materials to support sealants during application and at position required to produce optimum sealant movement capability. Do not leave gaps between ends of backer materials. Do not stretch, twist, puncture, or tear backer materials. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.

E. Install sealants at the same time backings are installed to completely fill recesses provided for each joint configuration and to produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

G. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

END OF SECTION 321373

SECTION 321413 - PEDESTAL MOUNT PAVERS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Precast composite concrete pavers..
   2. Pedestal support system

B. Related Work.
   1. Division 07 - Membrane roofing.
   2. Division 22 - Roof drains.
   3. Division 07 - Sheet Metal Flashing and Trim.

1.2 REFERENCES

A. Interlocking Concrete Pavement Institute (ICPI)
   1. Tech Spec technical bulletins

1.3 SUBMITTALS

A. Shop drawings: Indicate perimeter conditions, relationship to adjoining materials and assemblies, expansion and control joints, paving slab layout, patterns, color, arrangement, installation and setting details.
B. Four (4) pedestal samples.
C. Paving slabs:
   1. Two representative full-size samples of each slab type, thickness, color, finish. Select samples to indicate the extremes of color and texture expected in the finished installation.
   2. Accepted samples become the standard of acceptance for the work in this Section.
   3. Laboratory test reports certifying compliance of the paving slabs with CSA A231.1.
   4. Manufacturer's catalog literature and material safety data sheets for the safe handling of the specified materials and products.

1.4 QUALITY ASSURANCE

A. Paving Subcontractor Qualifications:
   1. Utilize an installer having successfully completed concrete paving slab installation similar in design, material, and extent indicated on this project.
   2. Utilize an installer holding a current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.
B. Regulatory Requirements and Approvals: [Specify applicable licensing, bonding or other requirements of regulatory agencies.].
C. Mock-Ups:
   1. Install a 7 ft x 7 ft (2 x 2 m) area.
   2. Use this area to determine pedestal height and shimming requirements, joint sizes, lines, laying pattern(s), color(s), and texture of the job.
   3. This area will be used as the standard by which the work will be judged.
   4. Subject to acceptance by owner, mock-up may be retained as part of finished work.
   5. If mock-up is not retained, remove and properly dispose of mock-up.

1.5 DELIVERY, STORAGE & HANDLING

A. General: Comply with Division 1 Product Requirement Section.

B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers packaging with identification labels intact.
   1. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.
   2. Deliver concrete paving slabs to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by forklift or clamp lift.
   3. Unload slabs at job site in such a manner that no damage occurs to the product.

D. Storage and Protection: Store materials protected such that they are kept free from mud, dirt, and other foreign materials.

1.6 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
   1. Do not install pedestals and slabs during heavy rain or snowfall.

1.7 MAINTENANCE

A. Extra Materials: Provide 2% additional material for use by Owner for maintenance and repair including pedestals. Provide minimum of 2 pavers of each color of accent pavers.

B. Slabs shall be the same production run as installed materials.

PART 2 PRODUCTS

2.1 CONCRETE PAVING SLABS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Wausau Tile, Type One Exposed Aggregate pavers or a comparable product by one of the following:
   1. Hanover Compensator System.
   2. Lehi Block Pavers.
   3. Stepstone, Inc.
   4. Westile

B. Paver Construction:
   1. Material Standard: Comply with CSA A231.1: 650 psi (4.5 MPa) average flexural strength. Freeze-thaw scaling testing requirements shall be waived for applications not exposed to freezing conditions.
   2. Color: 3 tone color system - 80% field color, 10% accent #1 and 10% accent #2.
   3. Size: 17 5/8 inches x 17 5/8 inches x 1-13/16 inches thick.
   4. Manufactured in a plant where paving products are certified by ICPI as having passed manufacturer designated ASTM, CSA requirements in this specification.
   5. Compression Strength: Each unit shall have a compression strength of 8,000 psi with no individual unit less than 6,500 psi when tested in accordance with ASTM C140.

6. Flexural Strength: Each unit shall have a flexural strenghth of 700 PSI when tested in accordancce with ASTEM C293.
7. Water absorption: Shall not be greater than 6% according to ASTM C140.
8. Freeze/thaw: Durability of the paver shall meet the freeze/thaw tests in accordance with Section 8 of ASTM C67. Specimens, when tested, shall have no breakage and not greater that 1% loss in dry weight of any individual unit when subject to 50 cycles of freeze/thaw.
9. Center load: Pavers shall support a minimum concentrated load of 1,850 lbs. when pressure is applied to a paver supported on four (4) corners. WT CL96

2.2 PEDESTAL SUPPORT SYSTEM

A. Basis-of-Design Product: Subject to compliance with requirements, provide Wausau Tile, Terra-System One Sloped Installation Method or a comparable product by one of the following:
1. Tabs and Shim Plates:
   a. SBR rubber tab units provide spacing tabs 3/16” or 1/8” allowing for drainage and air circulation. Tabs to have a shore hardness of 70, allowing for resiliency without sound transmission. Terra-Tab sizes to correspond with various sizes of pavers.
   b. Shim Plates (shims) are 1/8” and 1/4"thick and of various sizes to correspond with various size tabs. Shim Plates to be of the same material as the tab.
2. Adjustable Pedestals: To accommodate various pitches/slopes of project areas. Unit has an outside base diameter of 6 1/8” giving a contact surface area of 29 1/2 sq. inches. Unit telescopes from a minimum 2” to a maximum 5 1/2” and can tilt to a level plane. Terr-adjust extenders and reducers to be used in areas requiring over 5 1/2” or under 2” in height. Units to be high impact styrene. Tabs are used on top of this unit.
3. Stand Pedestals: Accommodate various pitches and height changes of the project area. Unit has outside dimension of 7”. Unit telescopes from a minimum of 2” to a maximum of 21” and can tilt to a level plane. Units to be high impact copolymer polypropelene tabs are used on top of this unit.
4. Extenders/Reducers: Extender gives an additional 4 ” adjustment to a maximum height of 10”. Reducer is made to accommodate height adjustment between 1/2" and 2”. Units to be high-impact styrene. Tab or shim plate with spacer unit are used on top of this unit.
5. Handle Units: Units to handle paver sizes 12” to 24” nominal, allowing installing contractor to set units into proper location with 3/16”or 1/8” joint between units. Also allows for removal or installing units without causing any damage to units or adjacent units, thus allowing inspection of utilities or drains at any time.
6. Other Accessory Materials: Shall be either provided by the manufacturer of the precast concrete pavers and precast units, or shall be specifically recommended by them.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Acceptance of Site Verification of Conditions:
1. Contractor shall inspect, accept and certify in writing to the slab installation subcontractor that roof conditions meet specifications for the following items prior to installation of concrete paving slabs.
   a. Verify that geotextiles, if applicable, have been placed according to drawings and specifications.

b. Verify that roof deck materials, thickness, surface tolerances and elevations conform to specified requirements.
c. Provide written test results for roof deck materials to the Owner, General Contractor and paving slab installation subcontractor.
d. Verify location, type, and elevations of edge restraints, drains, drain holes, holes and inlets.

2. Do not proceed with installation of bedding materials until roof conditions are corrected by the General Contractor or designated subcontractor.

3.2 EXAMINATION

A. Verify that all surfaces, membrane(s), protection board, insulation, drains, are free from dirt, oil, grease or any deleterious substances and debris which may prevent installation, drainage, and stability of the paving slab installation.
B. Verify that roof deck has a minimum of 2% slope to drains.
C. Do not begin paving work until such conditions have been corrected [to the Architect's satisfaction] and are ready to receive leveling materials and paving slabs.

3.3 INSTALLATION

A. Locate pedestals according to manufacturer’s recommendations and as indicated on the drawings.
B. Place paving slabs on pedestals so they are supported according to pedestal manufacturer’s recommendations.
C. Align pedestals in all directions and shim elevations of slabs as work progresses and according to the manufacturer’s recommendations.
D. Trim and remove uncovered portion of pedestals to fit tightly with slabs against parapets, walls, and protrusions in the roof. Cut paving slabs with a masonry saw to fit in these areas. Cut slabs without damage to exposed faces and edges. Cut units should be no smaller than [1/2] of a whole slab.
E. Maintain consistent joint widths and joints aligned in all directions as indicated on the drawings.
F. Do not install cracked or broken paving slabs.
G. Remove cut pieces and other debris from the surface and on the roof deck. Sweep slab surfaces clean.

3.03 FIELD QUALITY CONTROL

A. Check final surface elevations for conformance to drawings.
B. Lippage: Maximum 1/16 in. (1.5 mm) height variation between adjacent paving slabs.

3.04 CLEANING AND SEALING

A. Clean and seal concrete slabs in accordance with the manufacturer’s written recommendations.

3.05 PROTECTION

A. After work in this section is complete, the General Contractor shall be responsible for protecting work from damage due to subsequent construction activity on the site.

END OF SECTION 321413

SECTION 328400 – UNDERGROUND IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:

1. Furnish and install underground sprinkler irrigation system as described in Contract Documents complete with accessories necessary for proper function.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation Main Piping: 200 PSI.
2. Circuit Piping: 150 PSI.

B. Location of sprinklers and specialties: Design location is approximate. Make minor adjustments as necessary in order to provide proper coverage of all areas. Maintain head to head coverage in all lawn areas. Contact Landscape Architect if major discrepancies exist.

1.3 SUBMITTALS

A. Product Data:

1. Manufacturer's cut sheets for each element of system.
2. Parts list for operating elements of system.
3. Manufacturer's printed literature on operation and maintenance of operating elements of system.

B. Quality Assurance / Control:

1. Results of service pressure test before beginning work on system.
2. List of personnel who will be performing work of this Section with brief description of landscape work experience and training

C. Closeout:

1. Record Drawings:

a. As installation occurs, prepare accurate record drawing to be submitted before final inspection, including:

1) Detail and dimension changes made during construction.

2) Significant details and dimensions not shown in original Contract Documents.
3) Field dimensioned locations of valve boxes, manual drains, quick-coupler valves, control wire runs not in mainline ditch, and both ends of sleeves.
4) Take dimensions from permanent constructed surfaces or edges located at or above finish grade.
5) Take and record dimensions at time of installation.

b. Reduce copy of record drawing to half-size, color key circuits, and laminate both sides with 5 mil thick or heavier plastic. Locate in or near controller location or as directed by owner.

2. Operations And Maintenance Manual Data:

a. Instruction manual that contains complete instructions for system operation and maintenance, including winterizing.
b. Complete instructions on how to drain filter to prevent freezing.

D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Sprinkler Installation Company:

a. Produce certification of the following requirements before beginning work of this Section:

1) In irrigation system installation business for five years minimum providing quality labor and materials described in Contract Documents.
2) Evidence of completing five projects minimum of scope and quality equal to this project and in timely manner.
3) Certifiable list of suppliers from whom it will be obtaining materials used on this project.
4) Evidence that it utilizes employees with specified experience and in quantity sufficient to perform work of this Section within time limits established by Contract.

2. Workers:

a. Use only trained personnel familiar with required irrigation system installation procedures.
b. Perform installation under direction of foreman or supervisor with five years minimum experience in sprinkling system installations.

3. Regulatory Requirements:

a. Work and materials shall be in accordance with latest rules and regulations, and other applicable state or local laws. Nothing in Contract Documents is to be construed to permit work not conforming to these codes.

4. Pre-Installation Conference:

a. Schedule pre-installation conference before irrigation system installation begins. Demonstrate or describe method to be used to maintain head spacing from concrete and to stabilize heads.

1.5 DELIVERY, STORAGE, AND HANDLING

A. During delivery, installation and storage, protect materials from damage and prolonged exposure to sunlight.

1.6 SEQUENCING

A. Install sleeves at specified depth before installation of cast-in-place concrete site elements and paving.

1.7 WARRANTY

A. Standard one year guarantee shall include:

1. Filling and repairing depressions and replacing plantings and/or sod due to settlement of irrigation trenches.
2. Adjusting system to supply proper coverage of areas to receive water.
3. Ensuring system can be adequately drained and winterized.

1.8 OWNER'S INSTRUCTIONS

A. After system is installed and approved, instruct Owner's designated personnel in complete operation and maintenance procedures.

1.9 MAINTENANCE

A. Extra Materials:

1. Furnish following items before Final Closeout Review:

a. Two quick coupler keys with brass hose swivel.

PART 2 – PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Galvanized-Steel Pipe: ASTM A 53/A 53M, Standard Weight, Type E, Grade B.

1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless-steel pipe with threaded ends.

C. PVC Pipe: ASTM D 1785, PVC 1120 compound, schedule 40 and 80.

1. PVC Socket Fittings: ASTM D 2466, schedule 40 and 80.
2. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

2.2 PIPING JOINING MATERIALS

A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 MANUAL VALVES

A. Mainline Isolation Valves:

1. Description:

a. 1-1/2” Milwaukee galvanized non rising gate valve with cross-type operating handle designed to receive operating key.
b. Pressure Rating: 150 PSI minimum.
c. Body Material: Galvanized
d. End Connections: Matching piping.

B. Mainline Isolation Valve Casing:

1. Top Section: Telescoping, of length required for depth of burial of valve.
2. Barrel: Approximately 2 inch diameter or as necessary.
3. Plug: With lettering "WATER."
4. Bottom Section: With base of size to fit over valve.
5. Base Support: Wood frame.

C. Shutoff Rods for Mainline Isolation Valve Casings: Furnish two steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching isolation valve for project.

D. Manual Drain Valves:

1. Description:
   a. Brass ball valve with “T” handle on mainlines and in valve boxes on lateral lines.

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2.4 AUTOMATIC CONTROL VALVES

A. Plastic, Automatic Control Valves:

1. Manufacturer:

   a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings

2. Description:

   a. Rainbird PESB Series and XCZ Series Valves. Use Non-potable valves with purple handle.
   b. Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.5 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at water pressure noted in legend.

B. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:

1. Manufacturers:

   a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description:
3. Rainbird 5000 MPR series rotor with nozzles as indicated in legend.
3. Capacities and Characteristics:

   a. Flow: As noted in legend and on plans.
   b. Pop-up Height: 4” aboveground to nozzle.
   c. Arc: As noted in legend and on plans.
   d. Radius: As noted in legend and on plans.
   e. Inlet: 3/4 inch NPT

C. Plastic, Pop-up Spray Sprinklers:

1. Manufacturer:

   a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description:

a. Rainbird 1804-PRS-SAM (Use 1800 NP cover on all pop-up sprays).
b. Body Material: Plastic
b. Nozzle: Rainbird MPR and R13-18 Rotary Nozzles per legend.
c. Retraction Spring: Stainless steel.
d. Internal Parts: Corrosion resistant.
e. Pattern: As noted on legend and on plans.

3. Capacities and Characteristics:

a. Nozzle: Plastic
b. Flow: As noted in legend and on plans.
c. Pop-up Height: 4 inches aboveground to nozzle.
d. Arc: As noted in legend and on plans.
e. Radius: As noted in legend and on plans.
f. Inlet: 1/2 inch NPT.

D. Dripline System:

1. Manufacturers:

a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description:

a. Rainbird Landscape Dripline LD-09-12-100.
b. Rainbird XBS tubing with SXB360-SPKY emitters installed on Rainbird ¼ inch distribution tubing as noted in details.

3. Capacities and Characteristics:

a. Configuration: Modify location of dripline and drip tubing as necessary in order to water all plant material properly.
b. Flow: Adjust as necessary depending on type and size of plant and plant water requirements.
c. Arc: Adjust as necessary depending on type and size of plant.
d. Radius: Adjust as necessary depending on type and size of plant.

2.6 QUICK COUPLERS

A. Description: Rainbird 44NP

1. Locking-Top Option: Vandal-resistant locking feature. Include two matching keys. #2049.

2.7 CONTROLLERS

A. Manufacturers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description:

   a. Rainbird ESP-24MC-SS
   b. Each station is variable from approximately 0 minutes to 12 hours. Include switch for manual or automatic operation of each station.

3. Capacities and Characteristics:

   a. Exterior Control Enclosures: Weatherproof with locking cover and two matching keys; include provision for grounding.
   b. Body Material: Stainless-steel sheet metal.
   c. Mounting: Freestanding type for poured-in-place concrete base.
   d. Control Transformer: 24-V secondary, with primary fuse.
   e. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

      1) Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
      2) Nickel-Cadmium Battery: Automatically powers timing device during power outages.
      3) Surge Protection for both input power and field outputs.

4. Moisture Sensor: Bird RSD-CEx

   a. Install per details and per manufactures written specifications.

5. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

   a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
   b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
   c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

6. Concrete Base: Reinforced precast concrete not less than 24 inches square and a minimum of 6 inches greater in each direction than overall dimensions of controller. Include opening for wiring.

2.8 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Manufacturers:

a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

a. Size: As required for valves and service.
b. Shape: As noted in legend and on plans.
c. Sidewall Material: Plastic.
d. Cover Material: Plastic.

1) Lettering: "**IRRIGATION CONTROL VALVE”**

B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minus.

2.9 SECONDARY WATER FILTRATION

A. Filters:

1. Manufacturers:

a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings.

2. Description:

a. Amiad 2” Disc Filter.

3. Capacities and Characteristics:

a. Flow: As noted in manufactures specifications, in legend and on plans.
b. Installation: Install per manufactures written specifications.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Approved irrigation installer shall be pre-approved included in Construction Documents by Addendum.

3.2 EXAMINATION

A. Site Verification Of Conditions: Perform pressure test at stub-out on main water line provided for irrigation system, or at near-by fire hydrant. Notify Landscape Architect if pressures is over 100 psi or under 65 psi and it is determined that some re-design of system is necessary before beginning work on system.

3.3 PREPARATION

A. Protection:

1. Repair or replace work of this Section damaged during course of the Work at no additional cost to Owner. If damaged work is new, installer of original work shall perform repair or replacement.
2. Do not cut existing tree roots measuring over 2 inches in diameter in order to install sprinkler lines.
3. Layout of Irrigation Heads:

    a. Location of heads and piping shown on Drawings is approximate. Actual placement may vary slightly as is required to achieve full, even coverage without spraying onto buildings, sidewalks, fences, etc.
    b. During layout, consult with Landscape Architect to verify proper placement and make recommendations, where revisions are advisable.
    c. Minor adjustments in system layout will be permitted to avoid existing fixed obstructions.
    d. Make certain changes are documented on record drawings.

3.4 EARTHWORK

A. Excavating, trenching, and backfilling as specified in details and notes.

B. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 inch minus 12-18” below grade or as required. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

C. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of 18 inches below finished grade.
2. Circuit Piping: 12 inches.
3. Drain Piping: 12-18 inches as required
4. Sleeves: Minimum depth of 18” and maximum 24” below finished grade.

3.5 PIPING INSTALLATION

A. Location and Arrangement:

1. Drawings indicate location and arrangement of piping systems. Install piping as indicated.
   If deviations from plans are necessary, contact landscape architect.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with 2 inch or smaller pipe connection.

G. Install underground thermoplastic piping according to ASTM D 2774.

H. Lay piping on solid sub-base, uniformly sloped without humps or depressions.

I. Install PVC piping in dry weather when temperature is above 35 deg F. Allow joints to cure at least 24 hours at temperatures above 35 deg before testing.

3.6 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.7 VALVE INSTALLATION

A. Underground Automatic Control Valves: Install in valve boxes as specified in legend on plans with tops of valves flush with finish grade.

B. Underground Galv. Gate Valves: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.

1. Install valves and PVC pipe with restrained, gasketed joints.

C. Throttling Valves: Install 2” Brass pressure reducer if static pressure exceeds 100 PSI. Install in underground piping in box for automatic control valves.

D. Drain Valves: Install in-line with underground piping in boxes for automatic control valves.

3.8 SPRINKLER INSTALLATION

A. Before installation of sprinkler heads, open control valves and use full head of water to flush out system.

B. Set sprinkler heads and quick-coupling valves perpendicular to finish grade.

C. Do not install sprinklers using side inlets. Install using base inlets only, unless approved otherwise in writing by Landscape Architect.

D. Set sprinkler heads at a consistent distance from existing walks, curbs, and other paved areas and
to grade by using specified components or other method demonstrated in Pre-Construction Conference.

E. Install sprinklers after hydrostatic test is completed.

F. Install sprinklers at manufacturer's recommended heights.

G. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches
from other boundaries unless otherwise indicated.

3.9 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install exterior freestanding controllers on poured-in-place concrete bases.

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Wiring:

a. Tape control wire to side of main line every 10 feet. Where control wire leaves main or lateral line, enclose it in Class 200 PVC conduit.
b. Use waterproof wire connectors at splices and locate all splices within valve boxes. Use white or gray color for common wire and other colors for all other wire. Each common wire may serve only one controller.
c. Run one extra control wire from panel continuously from valve to valve throughout system similar to common wire for use if a wire fails. Wire shall be different color than all other wires, except use of green wire is not acceptable. Mark extra control wire in control box as an extra wire. Extend extra control wires 24 inches and leave coiled in each valve box.
d. Install control wire in separate sleeve under paved areas.

3.10 IDENTIFICATION

A. Identify system components.

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs for automatic controller.

1. Text: In addition to identifying unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Arrange valve stations to operate in an easy-to-view progressive sequence around building. Tag valves with waterproof labels showing final sequence station assignments.

3.11 SLEEVING

A. Sleeve water lines and control wires under walks and paving. Extend sleeves 18 inches minimum beyond walk or pavement edge. Cap sleeves until pipes and wires are installed to keep sleeve clean and free of dirt and debris.

B. Position sleeves with respect to buildings and other obstructions so pipe can be easily removed.

3.12 GRADES AND DRAINING

A. In localities where winterization is required, grade piping so system can be completely drained.

1. Slope pipe to drain to control valve box where possible.
2. Where this is not possible, slope pipe to a minimum number of low points. At these low points, install:

a. 1 inch brass ball valve for manual drain. Do not use automatic drain valves.
b. Install 2 inch Class 200 PVC pipe over top of drain and cut below finish grade.
c. Provide 2” snug cap. Install in valve box per details.
d. Provide two cubic feet pea gravel sump at outlet of each drain.
e. Slope pipes under parking areas or driveways to drain outside these areas.

f. Provide and install quick-coupling valve per plans for blowout of entire system. Install quick coupler valves with 2 lineal feet minimum of galvanized pipe between valve and main line.

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system to 100 PSI and test for leaks. Repair leaks and retest until no leaks exist. Notify Landscape Architect 2 days prior to test.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Inspections: Architect's irrigation design consultant, or certified water auditor recommended by consultant and approved in writing by Architect, will review irrigation system before substantial completion. Upon approval of system, reviewer will provide signed acceptance certificate to be included in Operations and Maintenance Manual. Certificate will include name and signature of reviewer, reviewer's company, date of review, and reviewer's telephone number.

C. Any irrigation product will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.14 ADJUSTING

A. Adjust settings of controllers as necessary. Adjust watering time of valves to provide proper amounts of water to all plants.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust heads to proper grade when turf is sufficiently established to allow walking on it without appreciable harm. Such lowering and raising of heads shall be part of original contract with no additional cost to Owner.

D. Adjust sprinkler heads for proper distribution and trim so spray does not fall on buildings.

E. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with or not more than 1/2 inch above finish grade.

3.15 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes may be joined with unions instead of joints indicated.

C. Underground irrigation main piping, 2 inch and smaller shall be as follows:

1. Schedule 40 PVC pipe; socket-type PVC fittings; and solvent-cemented joints.

D. Circuit piping 2 inches and smaller shall be as follows:

1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

E. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.

1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

F. Risers to Aboveground Drip and Specialties: Schedule 40 and 80, PVC pipe and socket fittings; and solvent-cemented joints as noted on details.

G. Drain piping shall be as follows :

1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

END OF SECTION 328400

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding.
2. Sodding.

1.2 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

H. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

I. Surface Soil: Whatever soil is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product certificates. Native seed mix and RTF Sod Blend

1.4 QUALITY ASSURANCE

A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1. Pesticide Applicator: State licensed, commercial.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

1.6 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:

1. Sodded Turf: 90 days

PART 2 - PRODUCTS

2.1 NATIVE SEEDING

A. Contractor to obtain the following seed mix with a certificate of authenticity from seed provider. Certificate to be presented to landscape architect prior to purchase of seed. All varieties to be listed. Any variation from the following seed mix to be approved by the landscape architect.

1. Slender Wheat Grass	18.75%
2. Sheep Fescue	5%
3. Sandberg Bluegrass	3.75%
4. Western Wheat Grass	20%
5. Thick Spike Wheat Grass	18.75%
6. Blue Flax	7.5%
7. California Poppy	7.5%
8. Blanket Flower	10%
9. Lanceleaf Coreopsis	7.5%
10. Rubber Rabbit Brush	.75%
11. Wyoming Big Sage	.5%

*Application rate: 20 lbs. /acre.

B. Seeding/maintenance procedure following seedbed preparation:

1. Assure that soil is non-compacted and weed free; a pre-emergent herbicide may be applied no later than 6 months prior to seeding.
2. Saturate soil 1-2 weeks before seeding. If weeds emerge, treat with RoundUp herbicide and wait 1 more week before seeding.
3. Soil shall be moist when seeding but not so wet that equipment leaves ruts. If soil is very dry water to 6-8" and wait 1-3 days until equipment can be driven across site without leaving ruts. Drill-seed indian ricegrass seed at 1.5" deep; Drill remaining grasses as close to 5/8 inch as possible, ***except*** sandberg bluegrass.
4. Bulk sandberg bluegrass with rice hulls or other suitable material. Broadcast onto surface. Rake or lightly drag.
5. Water (sprinklers) to saturate soil surface. Do not irrigate for 3 days. Thereafter, water as needed to keep soil moist *but not wet.* It is better to allow the soil surface to dry a little than to over-water.
6. Following establishment, deep-water (wet soil to 6-8") about once every month to keep grasses green if desired. (If not watered, grasses will turn brown but live.)
7. Treat with selective broadleaf herbicide as needed following establishment.
8. Do not fertilize the first year. Evaluate performance after one year to determine if low rate of nitrogen is needed.
9. Ideal seeding time is early - mid September (fewer weeds). Second best time is April.

2.2 TURFGRASS SOD

A. Turfgrass Sod: Approved sod complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Turfgrass Species: Sod of grass species as follows:

1. RTF SOD BLEND (Rhizomatous Tall Fescue): Installer to obtain a certificate of authenticity from grower and submit to landscape architect prior to delivery of sod.
2. Sod to adhere to the following specifications.
    a. 49.33% Barrington Tall Fescue
    b. 49.17% Labarinth (RTF) Tall Fescue
    c. 1.5% Inert Matter

2.3 FERTILIZERS

A. Apply a starter fertilizer immediately prior to and following installation with low nitrogen (N) 10-20-20.
B. A maintenance fertilizer should be applied in the spring, fall and early winter using a 21-7-14 product. Application rate to be 1 lb./ 200 sq. ft.

PART 3 - EXECUTION

3.1 TURF AREA PREPARATION

A. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
3. Spread planting soil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

    a. Reduce elevation of planting soil to allow for soil thickness of sod.

3.2 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 2 inches below sod.

3.3 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain height appropriate for species without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings.

C. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

3.4 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Planting soils.

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

C. Finish Grade: Elevation of finished surface of planting soil.

D. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

E. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

F. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

G. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

H. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

I. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

J. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

K. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, including soils.

B. Delivery receipt from nursery for all plant material received.

B. Samples of mineral/crushed stone and river cobble mulch.

C. Product certificates: Topsoil

D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year.

1.4 QUALITY ASSURANCE

A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1. Pesticide Applicator: State licensed, commercial.

B. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.

1. The soil-testing laboratory shall oversee soil sampling.
2. Report suitability of tested soil for plant growth.

a. State recommendations for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
b. Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.

C. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

D. Preinstallation Conference: Conduct conference at location and time to be determined. Contact Construction Administrator for more information.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do

not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

B. Handle planting stock by root ball.

C. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.6 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
b. Structural failures including plantings falling or blowing over.

2. Warranty Periods to begin following on-site inspection by landscape architect of all proposed plantings. A written notice will be provided to contractor and owner to initiate Warranty Period for the following periods:

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

1.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period for Trees and Shrubs: 12 months from date of written notice of completion from Landscape Architect. 2. Maintenance Period for Ground Cover and Other Plants:12 months from date of written notice of completion from Landscape Architect.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

2.2 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter as specified below in Table 2.

2.3 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

C. Planting Tablets: See drawing for spec and quantity requirements

2.4 PLANTING SOILS

A. Test existing topsoil.

a. Standards: A complete horticultural soils analysis will be conducted on the topsoil for the site before excavation begins. Owner's representative will analyze the soil and make the determination as to its quality according to criteria listed in Table 1 of this document. If topsoil is to be used on project for vegetative growth, it must meet minimum specifications defined in Table 1. Owner reserves the right to refuse or require amendment of any topsoil that does not meet the specifications in Table 1.

b. Method: Owner's representative will take topsoil samples concurrently with the geotechnical engineering samples. One soil sample will represent a maximum of 3 undisturbed acres of on-site topsoil. The soil sample shall comprise 10 representative core samples taken in a random zig-zag pattern across the 3 acres to be represented. The core samples will be obtained and placed in a container using a ¾-inch soil probe. The cores samples shall be mixed thoroughly and a quart of the mixed core samples shall be preserved for analysis purposes.

c. Cost of this testing will be paid by Contractor.

2. Protect existing topsoil quality

a. Excavation companies on site will be sensitive to topsoil quality and movement, and will not integrate soil not meeting topsoil criteria into designated topsoil stockpiling area.

b. If existing on-site soil fails in any of the requirements listed in Table 1, Contractor must remove soil from vegetative growth areas, or amend soil to meet specifications of Table 1, and/or import topsoil that meets the criteria. This work shall be in the contract and the Contractor will not be compensated for it on a Time and Materials basis. See section 3.3.

3. Subsoiling to relieve compaction

a. Before the time the topsoil is placed and preferably when excavation is completed, the subsoil shall be in a loose, friable condition to a depth of 12 inches and there shall be no erosion rills or washouts in the subsoil surface exceeding 3 inches in depth.

b. To achieve this condition, subsoiling and/or scarification of the subsoil will be required as directed by the owner's representative, wherever the subsoil has been compacted by equipment operation or has become dried out and crusted, and where necessary to obliterate erosion rills. Subsoiling shall be required to reduce soil compaction in all areas where plant establishment is planned. Subsoiling shall be performed by the prime or excavating contractor and shall occur before topsoil placement.

c. Subsoiled areas shall be loosened to less than 1400 kPa (200 psi) to a depth of 20 inches of the inplace topsoil. When directed by the Owners representative, the Contractor shall verify that the subsoiling work conforms to the specified depth. To test for conformance, the Contractor shall use a cone penetrometer that meets standard ASAE Soil Testing Specifications of a 13/16 inch insertion rate per second.

4. Subsoil treatment.

a. Excavated soil. All soils excavated for foundations or sidewalks that are B horizon (subsoil) soils shall be moved to non-plant growth area.

b. Topsoil covering operations shall be carried out as soon as possible after the subsoil has been finished to grade on any significant area.

c. Before topsoil is placed, all areas that receive plantings will meet compaction specifications in Section 3.

Tables

Table 1. Required soil tests and required parameters for final topsoil condition.
Depending on site history, additional tests may be required including tests for zinc, copper, manganese, boron, and sulfate.

Topsoil characteristic	Required final condition
Laboratory tests	
Soluble Salts (dS/m or mmho/cm)	<3
pH (-log [H+])	5.5 to 7.5
Sand (%)	< 70
Silt (%)	< 70
Clay (%)	< 30
Texture class*	Texture must be L, SiL, SCL, SL, or CL
Organic Matter (%)	> 5
Coarse fragments (%)	< 3
Nitrate-nitrogen (ppm or mg N/kg soil)	Report level to allow proper fertilization
Phosphorus (ppm or mg P/kg soil)	> 20
Potassium (ppm or mg K/kg soil)	> 150
Iron (ppm or mg Fe/kg soil)	> 10
Sodium Adsorption Ratio (SAR)*	< 3
Carbon:Nitrogen Ratio	<20:1
On-site tests	
Penetrability (ASAE Soil Testing Specifications of a 20 mm (13/16 inch) insertion rate per second)	<1400kPa (200 psi) down to a 10” depth
Bulk density (alternative to penetrability)	
Infiltration rates (inches/hour) (ASAE Soil Testing Specifications)	>0.6 - 2
Topsoil depth	>4” - >12”

*L = loam; SiL = Silt loam; SCL = sandy clay loam; SL = sandy loam; CL = clay loam; SiCL = Silty clay loam; LS = loamy sand; SC = sandy clay; SiC = silty clay; S = sand; Si = silt; C = clay. ** soil fragments > 2 mm in diameter. This guideline also includes no fragments larger than 1 inch in diameter.

Table 2. Required parameters for compost or soil amendments.

Characteristics	Compost soil amendment	Mulch or topdressing
Color	Dark brown to black	Light to dark brown – resembles shredded bark
Odor	Should have good earthy odor	Should have no objectionable odor
Particle Size	< ½ inch	> ½ inch
pH	5.0 – 8.0	5.0 – 8.0
Soluble Salt	< 5	< 6
Carbon-to-Nitrogen Ratio	< 20:1	> 50:1

5. Compliance with testing

a. Rights to test and inspect.

Owner's representative reserves the right to inspect jobsite for conditions that would prevent execution of work as specified.

Owner's representative reserves the right to take and analyze sample/s of materials for conformity to specifications at any time. Furnish samples upon request of the Owner's representative.

Immediately remove rejected materials from the site, at Contractors expense. The Contractor shall pay cost of testing materials.

b. Mandatory test points.

As described, existing topsoil must be tested before any excavation activities.

As described, the subsoil shall be inspected before topsoil placement.

As described, imported soils and amendments must be tested to ensure they meet the standards in Tables 1 and 2.

As described, contractor shall give Owner's representative 48 hour notice to inspect site during topsoil placement.

As described, topsoil shall be tested on-site before planting.

2.5 MULCHES

A. Organic Mulch: Ground or shredded bark mulch with max. size of 1" diam.

A. Mineral Mulch: See Finishes and Materials Chart on drawings sheet LS 101 and 102

2.6 WEED-CONTROL BARRIERS

A. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 5.0 oz./sq. yd. to be installed underall all stone mulch areas on plan. No fabric shall be placed under wood mulched planter areas.

2.7 PESTICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PLANTING AREA ESTABLISHMENT

A. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Spread specified planting soil to a depth of 4” in lawn areas and not less than 12” in planter areas and not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
2. Contractor shall give notice to Owner’s representative 48 hours before topsoil installation to allow inspection of the site during placement of topsoil. Owner will pay fees for site inspection.

B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.2 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

1. Excavate approximately three times as wide as ball diameter.
2. Excavate at least 12 inches wider than root spread.
3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.

B. Subsoil and topsoil removed from excavations may not be used as planting soil if found unsuitable for planting as specified in Table 1.

3.3 TREE, SHRUB, AND VINE PLANTING

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set stock plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.

1. Use planting soil for backfill.
2. Balled and Burlapped: After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting.

Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Container-grown: Carefully remove root ball from container without damaging root ball or plant.
4. Fabric Bag-Grown Stock: Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
5. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
6. Place planting tablets in each planting pit when pit is approximately one-half filled; Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
7. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.4 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

3.5 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.6 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees in Turf Areas: Apply organic mulch ring of 3-4” average thickness, with 4 foot radius around trunks or stems. Do not place mulch within 6inches of trunks or stems.
2. Organic mulch in Planting Areas: Apply 3 inch average thickness of mulch extending 12 inches (300 mm) beyond edge of individual planting pit or trench] and over whole surface of planting area as indicted on drawings and finish level with adjacent finish grades. Do not place mulch within 6 inches of trunks or stems.

3.7 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.

B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use practices to minimize the use of pesticides and reduce hazards.

D. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

E. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

END OF SECTION 329300

SECTION 330500 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping joining materials.
2. Dielectric fittings.
3. Sleeves.
4. Identification devices.
5. Grout.
6. Piping system common requirements.
7. Equipment installation common requirements.
8. Concrete bases.
9. Metal supports and anchorages.

1.2 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Identification devices.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness, unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Capitol Manufacturing Co.
    b. Central Plastics Company.
    c. Epco Sales, Inc.
    d. Hart Industries, International, Inc.
    e. Watts Water Technologies, Inc.
    f. Zurn Plumbing Products Group; Wilkins Div.
    g. As approved by engineer.

3. Description: Factory fabricated, union, NPS 2 (DN 50) and smaller.

    a. Pressure Rating: 150 psig minimum at 180 deg F (82 deg C).
    b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Capitol Manufacturing Co.
    b. Central Plastics Company.
    c. Epco Sales, Inc.
    d. Watts Water Technologies, Inc.
    e. As approved by engineer.

3. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.

    a. Pressure Rating: 150 psig minimum.
    b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Calpico, Inc.
    b. Lochinvar Corporation.
    c. As approved by engineer.

3. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 (DN 80) and smaller.

    a. Pressure Rating: 300 psig at 225 deg F.
    b. End Connections: Threaded.

E. Dielectric Nipples:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Perfection Corporation.
    b. Precision Plumbing Products, Inc.
    c. Victaulic Company.
    d. As approved by engineer.

3. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

    a. Pressure Rating: 300 psig at 225 deg F.
    b. End Connections: Threaded or grooved.

2.3 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Division 22 Section "Common Work Results for Plumbing."

B. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.4 IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

B. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

C. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

D. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers, extending 360 degrees around pipe at each location.

E. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

F. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

G. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils thick.

1. Width: 1-1/2 inches on pipes with OD, including insulation, less than 6 inches (150 mm); 2-1/2 inches for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

H. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Include 5/32-inch hole for fastener.

1. Material: 0.032-inch- thick, polished brass or aluminum.
2. Material: 0.0375-inch- thick stainless steel.
3. Material: 3/32-inch- thick plastic laminate with 2 black surfaces and a white inner layer.
4. Material: Valve manufacturer's standard solid plastic.
5. Size: 1-1/2 inches in diameter, unless otherwise indicated.
6. Shape: As indicated for each piping system.

I. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

J. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine

subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Thickness: 1/16 inch (1.6 mm), unless otherwise indicated.
3. Thickness: 1/16 inch, for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

K. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:

   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

7. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

2.5 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 and Smaller: Dielectric unions.
2. NPS 2-1/2 and Larger: Dielectric flanges.

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 and Smaller: Dielectric couplings or dielectric nipples.
2. NPS 2-1/2 and Larger: Dielectric nipples.

3.2 PIPING INSTALLATION

A. Install piping according to the following requirements and Division 33 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Sleeves are not required for core-drilled holes.

J. Permanent sleeves are not required for holes formed by removable PE sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 33 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. Soldered Joints: Apply ASTM B 813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.

I. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric fittings at connections of dissimilar metal pipes.

3.5 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

C. Install equipment to allow right of way to piping systems installed at required slope.

3.6 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
2. Locate pipe markers on exposed piping according to the following:

a. Near each valve and control device.
b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
d. At manholes and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Concrete Paving”.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.9 GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 330500

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SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes gravity-flow, nonpressure storm drainage outside the building, with the following components:

1. Cleanouts.
2. Precast concrete manholes.

1.2 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For manholes and catch basins. Include plans, elevations, sections, details, and manhole frames and covers and catch basin frames and grates.

C. Coordination Drawings: Show pipe sizes, locations, and elevations.

D. Field quality-control test reports. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 10 and Smaller: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
2. Corrugated PE Pipe and Fittings NPS 12 and Larger: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
3. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.4 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

B. PVC Sewer Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-1 wall thickness, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.5 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded Flexible Couplings: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Company; a division of MCP Industries, Inc.
e. NDS Inc.
f. Plastic Oddities, Inc.
g. As approved by engineer.

D. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

    a. Cascade Waterworks Mfg.
    b. Dallas Specialty & Mfg. Co.
    c. Mission Rubber Company; a division of MCP Industries, Inc.
    d. As approved by engineer

E. Ring-Type Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

1. Manufacturers:

    a. Fernco Inc.
    b. Logan Clay Products Company (The).
    c. Mission Rubber Company; a division of MCP Industries, Inc.
    d. As approved by engineer.

2.6 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches minimum, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
8. Steps: Individual FRP steps, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
11. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch minimum width flange and 26-inch diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

    a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.

2.7 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.8 CATCH BASINS

A. Standard Precast Concrete Catch Basins: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
2. Top Section: Eccentric-cone type unless flat-slab-top type is indicated.
3. Joint Sealant: ASTM C 990, bitumen or butyl rubber.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch ID by 7- to 9-inch riser with 4-inch minimum width flange, and 26-inch diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Pipe couplings and fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.

a. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
b. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

B. Gravity-Flow, Nonpressure Sewer Piping: Use the following pipe materials for each size range:

1. NPS 3 to NPS 6 (DN 80 to DN 150): Hub-and-spigot, Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. NPS 3 to NPS 6 (DN 80 to DN 150): Corrugated PE drainage pipe and fittings, soiltight couplings, and coupled joints.
3. NPS 3 to NPS 6 (DN 80 to DN 150): PVC sewer pipe and fittings, gaskets, and gasketed joints.
4. NPS 8 to NPS 15 (DN 200 to DN 375): Hub-and-spigot, Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
5. NPS 8 to NPS 15 (DN 200 to DN 375): Corrugated PE drainage pipe and fittings, soiltight couplings, and coupled joints.
6. NPS 8 to NPS 15 (DN 200 to DN 375): PVC sewer pipe and fittings, gaskets, and gasketed joints.
7. NPS 18 to NPS 30 (DN 450 to DN 750): Corrugated PE pipe and fittings, soiltight couplings, and coupled joints.
8. NPS 18 to NPS 30 (DN 450 to DN 750): PVC sewer pipe and fittings, gaskets, and gasketed joints.

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
3. Install piping with 36-inch (915-mm) minimum cover.
4. Install piping below frost line.
5. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

F. Clear interior of piping and manholes of dirt and superfluous material as work progresses.

3.3 PIPE JOINT CONSTRUCTION

A. Basic pipe joint construction is specified in Division 33 Section "Common Work Results for Utilities." Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-gasket joints.
4. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use light-duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use medium-duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use extra-heavy-duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.5 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, unless otherwise indicated.

3.6 CATCH BASIN INSTALLATION

A. Set frames and grates to elevations indicated.

3.7 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."

B. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

3.8 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Air Tests: Test storm drainage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Option: Test plastic gravity sewer piping according to ASTM F 1417.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 334100

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