

# **Project Manual**

**for**

**Gunther Trades 5<sup>th</sup> Floor**

**HVAC Improvement Project**

**Utah Valley University – Orem, Utah**

**State of Utah DFCM**

**DFCM Project Number: 06067790**

**Issue for Bid  
March, 2010**



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State of Utah DFCM – Gunther Trades 5<sup>th</sup> Floor / UVU  
 HVAC Improvements  
 Issue for Bid  
 22078.01.00

UTAH DFCM Project Number: 06067790  
 Salt Lake City, Utah

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**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Work covered by Contract Documents.
- B. Agreement.
- C. Work sequence.
- D. Contractor use of premises.
- E. Owner occupancy.

1.02 WORK COVERED BY CONTRACT DOCUMENTS

- A. Work of this Agreement comprises general construction of the HVAC equipment to replace the existing HVAC equipment which serves part of the 5<sup>th</sup> floor of the existing Gunther Trades Building located on the property of Utah Valley University, in Orem, Utah. Work of this agreement also comprises all of those trades related to support, operation, connection, and concealment of said HVAC equipment.

1.03 AGREEMENT

- A. Construct Work under single lump sum Agreement.

1.04 WORK SEQUENCE

- A. Construct Work in stages to accommodate Owner's use of premises during construction period; coordinate construction schedule and operations with Owner's Representative.
  - 1. The contractors shall submit a schedule of work such that the demolition and replacement of AC-1 shall minimize the impact to the existing typical operating schedule and the existing noise level of the Trades classrooms and workshops.
  - 2. Air Handler demolition and installations are to occur during the shutdown of the 5<sup>th</sup> floor. Coordinate exact dates with Owner.
  - 3. After field measurements have been completed, the contractor shall submit factory design shop drawings of the equipment.
  - 4. Once all shop drawings have been reviewed, fabrication of the new units may begin.
  - 5. Prior to scheduled shutdown of the Trades Facility, the contractors shall mobilize their equipment and manpower to be ready for demolition and construction.
  - 6. Prior to scheduled shutdown of the Trades Facility, the contractors shall have received the new replacement air handling units and related equipment at the site.
  - 7. Modify existing fire suppression system (i.e. add/relocate piping, add/relocate sprinkler heads, etc.) within project area to match new ceiling tile and to conform with NFPA 13 requirements.
  - 8. Demolition of the existing unit and installation of the new units shall commence as shown on drawings.
  - 9. Salvage all existing VAV controllers within project area and return to Owner.
  - 10. Coordinate all work with Owners.
- B. The contractor's schedule of work shall be broken out in two phases. Phase 1 shall include all of the classroom, lab, office, restroom, photography areas, and adjoining hallways as designated on the plans. Phase 2 shall include the commercial print shop area. Phase 2A shall include replacement of HVAC equipment in the multi-use room #521, which shall be an add alternate to the contract. The phasing scheme shall include but not be limited to the following major tasks of work:
  - 1. Evacuate Phase 1 area of owners' equipment, furniture, and materials.
  - 2. Demolish mechanical equipment in Phase 1 area.

3. Modify existing air handling system to cut off and disconnect HVAC service to Phase 1 area but be able to continue service to the print shop area.
  4. Install Phase 1 replacement mechanical equipment and other trades equipment in Phase 1 as shown on the plans.
  5. Provide full operation of Phase 1 HVAC equipment and related trades as shown on the plans prior to re-occupancy by owners and/or owner's tenants.
  6. Coordinate exact demolition and construction schedule of Phase 2 with the owners with regard to the operating hours of the print shop. The print shop shall be able to continue its normal production schedule as much as possible during demolition and construction of Phase 2 with minimal shutdowns and minimal disturbances to the print shop production equipment. The demolition and construction schedule of Phase 2 shall occur during the least occupied or least productive hours of the print shop, such as during evening, weekend, or holiday hours. If the contractor's work schedule coincides or overlaps with the print shop production schedule, then the contractors shall provide temporary HVAC service during those times. The contractors shall take measures to protect the print shop production equipment from damages which may occur as a result of their demolition and construction activities.
  7. Demolish existing mechanical equipment in the Phase 2 area.
  8. Install Phase 2 replacement mechanical equipment and other trades equipment in Phase 2 as shown on the plans.
  9. Provide full operation of Phase 2 HVAC equipment and related trades as shown on the plans prior to re-occupancy by owners and/or owner's tenants.
- C. Additive Alternate No.1:
1. Modify and/or replace the existing Architectural, Mechanical, and Electrical components in the multi-use room #521. See drawings for additional information.
- D. Additive Alternate No.2:
1. Replace all existing light fixtures and exit signs within the project area with the same quantity of new energy efficient light fixtures and exit signs. New fixtures shall match existing lamp quantity.
- E. Additive Alternate No.3:
1. Due to damage caused during the removal of ceilings, ducting, and other related HVAC construction work the carpet tile in the affected 'construction zone' hallways may be removed and replaced with new. When new carpet tile is to be replaced the contractor shall:
    - a. Remove existing carpet tile and rubber wall base with a minimal amount of destruction to adjoining surfaces.
    - b. Remove and store for reuse where practical, the existing thresholds and flooring transition strips.
    - c. Dispose of and/or recycle carpet tiles and rubber base according to UVU's or the manufacturer's recycle program.
    - d. Patch and repair any damage to concrete floor and sheetrock wall in the process of removing adhesives in order to prep surfaces for new materials.
    - e. Repaint wall where needed to cover any wall repairs with paint matching in color and texture of existing. Where walls short in length need to be repainted due to damage at the base the contractor shall repaint entire height of wall for consistent appearance. Where longer walls need new paint only at the base, the contractor may opt to feather the paint at the lower portion of the wall (ie up to 24") in lieu of painting full height as long as the difference between new and old paint is not clearly visible.
    - f. Install new carpet tiles throughout construction area to match existing color, pattern, size and style as per UVU standard specifications.
    - g. Install new rubber base to match existing, size, style, and color.
    - h. Reinstall existing thresholds and transition strips where such materials are almost 'like new' in appearance or install new materials if prior removal damaged the thresholds and transition strips.

## 1.05 CONTRACTOR USE OF PREMISES

- A. Contractor shall have limited use of premises as designated by the Owners for execution of Work.
- B. Limit Contractor's use of premises for Work and for storage, to allow for:
  - 1. Work by other contractors.
  - 2. Owner occupancy and security.
- C. Coordinate use of premises under direction of Owner. Contractor shall confine construction equipment, storage of materials and equipment and operations of workers to areas permitted by law, ordinances, permits, or requirements of Contract Documents, and shall not unreasonably encumber premises with construction equipment or other material or equipment.
- D. Assume full responsibility for protection and safekeeping of items under this Agreement, stored on Site.
- E. Move any stored items, under Contractor's control, which interfere with operations of Owner or separate contractor.
- F. Obtain and pay for use of additional storage or Work areas needed for operations.

1.06 OWNER OCCUPANCY

- A. Owner will occupy premises during entire period of construction for conduct of its normal operations. Cooperate with Owner's Representative in all construction operations to minimize conflict, and to facilitate Owner usage.
- B. Contractor shall at all times conduct its operations as to ensure least inconvenience to Owner and their subcontractors.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Procedures for preparation and submittal of applications for payment.

1.02 RELATED SECTIONS

- A. Section 01 33 00 - Submittal Procedures.
- B. Section 01 70 00 - Execution and Closeout Requirements.

1.03 FORMAT

- A. Contractor's electronic media driven form including continuation sheets when required.
- B. For each item, provide a column for listing each of the following:
  1. Item Number.
  2. Description of work.
  3. Scheduled Values.
  4. Previous Applications.
  5. Work in Place and Stored Materials under this Application.
  6. Authorized Change Orders.
  7. Total Completed and Stored to Date of Application.
  8. Percentage of Completion.
  9. Balance to Finish.
  10. Retainage.

1.04 PREPARATION OF APPLICATIONS

- A. Present required information on electronic media printout.
- B. Execute certification by signature of authorized officer.
- C. List each authorized Change Order as an extension on AIA G703 - Continuation Sheet, listing Change Order number and dollar amount as for an original item of Work.
- D. Prepare Application for Final Payment as specified in Section 01 70 00.

1.05 SUBMITTAL PROCEDURES

- A. Submit three copies of each Application for Payment.
- B. Submit an updated construction schedule with each Application for Payment.
- C. Payment Period: Submit at intervals stipulated in the Agreement.
- D. Submit with transmittal letter as specified for submittals in Section 01 33 00.

1.06 SUBSTANTIATING DATA

- A. When Owner requires substantiating information, submit data justifying dollar amounts in question.
- B. Provide one copy of data with cover letter for each copy of submittal. Show application number and date, and line item by number and description.

- C. Include the following with the application:
  - 1. Partial release of liens from major subcontractors and vendors.
  - 2. Affidavits attesting to off-site stored products.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

## **PART 1 GENERAL**

### 1.01 COORDINATION AND PROJECT CONDITIONS

- A. Coordinate scheduling, submittals, and Work of the various sections of the Project Manual to ensure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. Coordinate space requirements, supports, and installation of mechanical and electrical Work which are indicated diagrammatically on Drawings.
- C. Coordinate completion and clean-up of Work of separate sections in preparation for Substantial Completion and for portions of Work designated for Owner's occupancy.
- D. After Owner occupancy of premises, coordinate access to site for correction of defective Work and Work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

### 1.02 COPIES OF DRAWINGS AND PROJECT MANUALS

- A. Revised project manuals, if required, will be provided by Owner to show authorized changes or extra Work under provisions of Item "A." preceding.
- B. After Notice of Award, Contractor may obtain, at no charge, up to 5 printed or hard copies of the Drawings and Project Manual and one set in electronic format. Additional copies will be furnished upon request at the cost of reproduction plus handling charge.
- C. Additional copies of project manuals and half-size and full-size Drawings may be obtained under following conditions:
  - 1. Project manuals:
    - a. Furnished at Owner's reproduction cost plus handling charge.
    - b. If Contractor's requirement for additional project manuals necessitates reprinting of project manuals, Contractor shall pay entire cost of such reprinting.
    - c. Partial sets of project manuals will not be provided.
  - 2. Half-size Drawings:
    - a. Furnished at Owner's reproduction cost plus handling charge.
    - b. If Contractor's requirement for additional Drawings necessitates reprinting of half-size Drawings, Contractor shall pay entire cost of such reprinting.
  - 3. Full-size Drawings:
    - a. Complete sets of full-size Drawings may be purchased from Engineer at Engineer's reproduction cost plus handling charge per set.
- D. Revised Drawings and project manuals, if required, will be provided by Engineer to show authorized changes or extra Work under following conditions:
  - 1. Project manuals: Furnished at no charge, in same quantity as original issuance.
  - 2. Half-size Drawings:
    - a. Half-size Drawings will be available as revised Drawings.
    - b. One revised, complete set of half-size Drawings will be issued, at no charge, for each half-size set originally issued and for each half-size set purchased by Contractor after Notice of Award.
  - 3. Full-size Drawings:
    - a. Full-size Drawings will not be available as revised Drawings.

## 1.03 PROJECT SITE ADMINISTRATION

- A. Contractor shall provide competent, suitably qualified personnel to survey and lay out Work and perform construction as required by Contract Documents. Contractor shall at all times maintain good discipline and order at site.
- B. Except in connection with safety or protection of persons or Work or property at site or adjacent thereto, and except as otherwise indicated in Contract Documents, all Work at site shall be performed during regular working hours, and Contractor shall not permit overtime work or performance of Work on Saturday, Sunday, or any legal holiday without Owner's written consent given after prior written notice to Owner.
- C. Incompetent or incorrigible employees shall be dismissed from Work by Contractor or its representative when requested by Owner, and such persons shall not again be permitted to return to Work without written consent of Owner.
- D. Workmanship shall be of best quality.

## 1.04 PROJECT MEETINGS

- A. Representatives of Contractor, Subcontractors and suppliers attending meetings shall be qualified and authorized to act on behalf of entity each represents.
- B. Preconstruction meeting:
  - 1. Owner will schedule a meeting after 15 days after Notice of Award.
  - 2. Location: Gunther Trades Building, Utah Valley University, Orem, UT.
  - 3. Attendance:
    - a. Owner's representative.
    - b. Contractor's superintendent.
    - c. Major Subcontractors.
    - d. Major suppliers.
    - e. Others as appropriate.
  - 4. Agenda:
    - a. Execution of Owner-Contractor Agreement.
    - b. Submission of executed bonds and insurance certificates.
    - c. Distribution of Contract Documents.
    - d. Submission of list of Subcontractors and progress schedule.
    - e. Designation of personnel representing the parties in Contract.
    - f. Procedures and processing of field decisions, submittals, substitutions, applications for payments, proposal request, Change Orders, and Contract closeout procedures.
    - g. Scheduling.
  - 5. Record minutes and distribute copies within 2 days after meeting to participants, with copies to Owner, participants, and those affected by decisions made.
- C. Progress meetings:
  - 1. Schedule and administer meetings throughout progress of the Work at periodic intervals.
  - 2. Owner will hold called meetings as required by progress of Work.
  - 3. Location of meetings: Gunther Trades Building, Utah Valley University, Orem, UT.
  - 4. Owner will make arrangements for meetings, prepare agenda with copies for participants, preside at meetings.
  - 5. Attendance:
    - a. Contractor and Subcontractors as appropriate to agenda.
    - b. Suppliers as appropriate to agenda.
    - c. Others.
  - 6. Suggested agenda:
    - a. Review, approval of minutes of previous meeting.
    - b. Review of Work progress since previous meeting.
    - c. Field observations, problems, conflicts.

- d. Problems which impede construction schedule.
- e. Review of off-site fabrication, delivery schedules.
- f. Corrective measures and procedures to regain projected schedule.
- g. Revisions to construction schedule.
- h. Progress, schedule, during succeeding Work period.
- i. Coordination of schedules.
- j. Review submittal schedules; expedite as required.
- k. Maintenance of quality standards.
- l. Pending changes and substitutions.
- m. Review proposed changes for:
  - 1) Effect on construction schedule and on completion date.
  - 2) Effect on other contracts of Project.
  - 3) Other business.
- 7. Record minutes and distribute copies within 2 days after meeting to participants, with copies to Owner, participants, and those affected by decisions made.

## **PART 2 PRODUCTS**

NOT USED

## **PART 3 EXECUTION**

### **3.01 CUTTING AND PATCHING**

- A. Employ skilled and experienced installer to perform cutting and patching.
- B. Submit written request in advance of cutting or altering elements which affect:
  - 1. Structural integrity of element.
  - 2. Integrity of weather-exposed or moisture-resistant elements.
  - 3. Efficiency, maintenance, or safety of element.
  - 4. Visual qualities of sight exposed elements.
  - 5. Work of Owner or separate Contractor.
- C. Execute cutting, fitting, and patching including excavation and fill, to complete Work, and to:
  - 1. Fit the several parts together, to integrate with other Work.
  - 2. Uncover Work to install or correct ill-timed Work.
  - 3. Remove and replace defective and non-conforming Work.
  - 4. Remove samples of installed Work for testing.
  - 5. Provide openings in elements of Work for penetrations of mechanical Work.
- D. Execute work by methods to avoid damage to other Work, and which will provide proper surfaces to receive patching and finishing.
- E. Cut concrete materials using masonry saw or core drill.
- F. Restore Work with new products in accordance with requirements of Contract Documents.
- G. Refinish surfaces to match adjacent finishes. For continuous surfaces, refinish to nearest intersection; for an assembly, refinish entire unit.
- H. Identify hazardous substances or conditions exposed during the Work to the Engineer for decision or remedy.

END OF SECTION

**PART 1 GENERAL**

1.01 SUBMITTAL PROCEDURES

A. Deliver or email submittals to person listed below when required by Specification Sections:

1. Engineer: Stanley Consultants, Inc.  
Mr. Dan Rollins  
Email: rollinsdan@stanleygroup.com  
Stanley Consultants, Inc  
383 W Vine St  
Suite 400  
Salt Lake City, UT 84123

B. Submittals shall be in English language.

C. Weights, measures, and units shall be English units.

D. Symbols and drawings shall conform to ANSI Y32.2/IEEE 315/CSA Z99.

1.02 CONTRACTOR RESPONSIBILITIES

A. Review submittals prior to submission.

B. Determine and verify:

1. Field measurements.
2. Field construction criteria.
3. Catalog numbers and similar data.
4. Conformance to Specifications.

C. Coordinate each submittal with other submittals and with requirements of Work and of Contract Documents.

D. Notify Engineer in writing, at time of submission, of any deviations in submittals from requirements of Contract Documents. Any such deviations permitted by Engineer & Owner will require modifications of Contract Documents.

E. Provide space on Shop Drawings for Contractor and Engineer stamps.

F. When Shop Drawings are revised for resubmission, identify all changes made since previous submission.

G. Submittals containing language imposing duties on others (such as verification of dimensions or supply of related information) inconsistent with contract language shall be null and void.

H. Submittals shall not be used as media for inquiries for information or for verification of information that must be supplied by others to Contractor. Inquiries or verification of information shall be made by separate Contractor submittal using Request for Information (RFI) process.

I. Begin no fabrication or Work which requires submittal review until return of submittals by Engineer with stamp, as either "Reviewed", "Reviewed as Noted", or "Reviewed as Noted-Resubmit."

J. Distribute copies of reviewed submittals that carry Engineer stamp as either "Reviewed" or "Reviewed as Noted" as appropriate. Instruct parties to promptly report any inability to comply with requirements.

K. Submittals not requested will not be recognized or processed.

### 1.03 OWNER DUTIES

- A. Review required submittals with reasonable promptness and in accord with schedule, only for general conformance to design concept of Project and compliance with information given in Contract Documents. Review shall not extend to means, methods, sequences, techniques, or procedures of construction or to safety precautions or program incident thereto. Review of a separate item as such will not indicate approval of assembly in which item functions.
- B. Affix stamp and initials or signature, and indicate requirements for resubmittal, or review of submittal. Engineer's action on submittals is classified as follows:
  - 1. Reviewed: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents. Contractor may proceed with fabrication of work in submittal.
  - 2. Reviewed As Noted: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents, except as noted by reviewer. Contractor may proceed with fabrication of work in submittal with modifications and corrections as indicated by reviewer.
  - 3. Reviewed As Noted-Resubmit: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents, except as noted by reviewer. Contractor may proceed with fabrication of work in submittal with modifications and corrections as indicated by reviewer. Contractor shall make any corrections indicated by reviewer and resubmit for review.
  - 4. Resubmit: Submittal has been reviewed and appears not to be in conformance to design concept of Project or with Contract Documents. Contractor shall not proceed with fabrication of work in submittal, but instead shall make any corrections required by reviewer and resubmit for review.
  - 5. Returned without Review: Submittal is being returned without having been reviewed because: 1) not required by Contract Documents; 2) grossly incomplete; 3) indicates no attempt at conformance to Contract Documents; 4) cannot be reproduced; 5) lacks Contractor's completed approval stamp; or 6) lacks design professional's seal when required by law or Contract Documents. If submittal is required by Contract Documents, Contractor shall not proceed with Work as detailed in submittal, but instead shall correct defects and resubmit for review.
  - 6. For Information Only: Submittal has not been reviewed but is being retained for informational purposes only.
  - 7. Void: Submittal is voided because it is no longer required or has been superseded by another submittal.
- C. Return 1 copy of submittals to Contractor. Contractor shall make additional copies as required.
- D. Review of submittals shall not relieve Contractor from responsibility for any variation from Contract Documents unless Contractor has, in writing, called Owner's attention to such variation at time of submission, and Owner has given written concurrence pursuant to Contract Documents to specific variation, nor shall any concurrence by Owner or other reviewer relieve Contractor from responsibility for errors or omissions in submittals.

### 1.04 SHOP DRAWINGS SUBMITTALS

- A. Submit for review for limited purpose of checking for conformance to information given and design concept expressed in Contract Documents. Produce copies and distribute in accordance with article "Submittal Procedures" and for record documents purposes as described in Section 01 70 00.
- B. Designate in construction schedule, or in separate coordinated submittal schedule, dates for submission and dates that reviewed submittals will be needed.
- C. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in Work or in work of other contractors.
- D. Present in clear and thorough manner, complete with respect to dimensions, design criteria, materials of construction, and like information to enable review of information as required.

- E. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Drawings.
- F. Indicate special utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- G. Equipment which is identified on Contract Documents with tag number or name shall be identified on Shop Drawing with same tag.
- H. Schedule submittals to expedite Project. Coordinate submission of related items.
- I. For each submittal for review, allow 7 days excluding delivery time to and from Contractor.
- J. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of completed Work.
- K. Shop Drawings may be submitted in electronic format.
  - 1. Submit electronic copy on E-mail files.
  - 2. Text documents shall be submitted in .pdf format.
  - 3. Drawings shall be submitted in .pdf or .tif format.
  - 4. Electronic submittal shall be suitable for reproduction in black and white.
- L. Number required:
  - 1. Submit number of opaque reproductions which Contractor, Engineer and/or approving agency (ies) requires .
  - 2. If Shop Drawings are not submitted in electronic format, submit copies of each Shop Drawing as required by Engineer.
  - 3. Copies of Shop Drawings submitted shall be black line on white background.
  - 4. Shop Drawings shall be suitable for reproduction in black and white. Shop Drawings submitted which are not suitable for reproduction will not be reviewed.
  - 5. Drawings larger than 8-1/2" x 11" shall be rolled.
- M. Submittals shall contain:
  - 1. Date of submission and dates of any previous submissions.
  - 2. Project title and number.
  - 3. Contract identification.
  - 4. Names of:
    - a. Contractor.
    - b. Supplier.
    - c. Manufacturer.
  - 5. Identification of product, with Specification section number and article number.
  - 6. Field dimensions, clearly identified as such.
  - 7. Relation to adjacent or critical features of Work or materials.
  - 8. Applicable standards, such as ASTM or Federal Specification numbers.
  - 9. Identification of deviations from Contract Documents.
  - 10. Identification of revisions on re-submittals.
  - 11. An 8" x 3" blank space for Contractor and reviewer stamps.
  - 12. Indication of Contractor's approval, initialed or signed, with wording substantially as follows:

"Contractor represents to Engineer that Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data, or assumes full responsibility for doing so and has reviewed or coordinated each submittal with requirements of Work and Contract Documents." Test reports:

    - 1. Submit for Engineer's knowledge as contract administrator.
    - 2. Submit test reports for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

- O. Certificates:
  - 1. When specified in individual specification sections, submit certification by manufacturer, installation/application subcontractor.
  - 2. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
  - 3. Certificates may be recent or previous test results on material or product, but must be acceptable to reviewer.
- P. Erection drawings:
  - 1. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
  - 2. Data indicating inappropriate or unacceptable Work may be subject to action by Owner.
- Q. Operations and maintenance manuals:
  - 1. Designate in construction schedule, or in separate coordinated schedule, dates for submission and dates that reviewed operations and maintenance manuals will be needed.
  - 2. Operations and maintenance manuals shall be presented in clear and thorough manner, complete with respect to dimensions, design criteria, materials of construction, and like information to enable reviewer to review information as required. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Drawings.

#### 1.05 RESUBMISSION REQUIREMENTS

- A. Make any corrections or changes in submittals required by Owner and resubmit until stamped as either "Reviewed," "Reviewed as Noted," or "For Information Only."
- B. Text and depictions changed on Submittal shall be back-circled (clouded).
- C. Engineer will assume that portions of Submittal not back-circled have not been changed by Contractor from previous submission.
- D. Indicate revision number and date in document revision block.

#### 1.06 DISTRIBUTION

- A. Distribute reproductions of Shop Drawings which carry Engineer stamp as either "Reviewed" or "Reviewed as Noted" to:
  - 1. Job site file.
  - 2. Record Documents file.
  - 3. Other affected contractors.
  - 4. Subcontractors.
  - 5. Supplier or fabricator.

#### 1.07 CONSTRUCTION PROGRESS DOCUMENTATION

- A. Construction progress schedules:
  - 1. Submit initial schedules to Owner within 7 days after date of Owner-Contractor Agreement. After review, resubmit required revised data within 5 days.
- B. Form of schedules:
  - 1. Prepare schedules in form of horizontal bar chart.
    - a. Provide separate horizontal bar for each trade or operation.
    - b. Horizontal time scale: Identify first work day of each week.
    - c. Scale and spacing: To allow space for notations and future revisions.
  - 2. Format of listings: Chronological order of start of each item of Work.
- C. Construction progress schedule shall show:

1. Complete sequence of construction by activity, with Contract Price breakdown at each stage.
  2. Dates for beginning, and completion of, each major element of construction specifically listing:
    - a. Site clearing.
    - b. Site utilities.
    - c. Foundation Work.
    - d. Structural framing.
    - e. Subcontractor Work.
    - f. Equipment installations.
    - g. Finishes.
  3. Projected percentage of completion for each item, as of first day of each month.
- D. Submittal schedule shall show:
1. Dates for Contractor's submittals.
- E. Progress revisions:
1. Indicate progress of each activity to date of submission.
  2. Show changes occurring since previous submission of schedule:
    - a. Major changes in scope.
    - b. Activities modified since previous submission.
    - c. Revised projections of progress and completion.
    - d. Other identifiable changes.
  3. Provide narrative report as needed to define:
    - a. Problem areas, anticipated delays, and impact on schedule.
    - b. Corrective action recommended, and its effect.
    - c. Effect of changes on schedules of other prime contractors.
- F. Distribution copies of reviewed schedules to:
1. Job site file.
  2. Subcontractors.
  3. Other concerned parties.
- G. Instruct recipients to report promptly to Contractor, in writing, any problems anticipated by projects shown in schedules.

#### 1.08 SUBMITTAL TRANSMITTAL FORM PROCEDURES

- A. Submittals shall be accompanied by completed copies of Submittal Transmittal form as required by Owner.
- B. Submit 5 copies of transmittal form for initial submittals and resubmittals. Sequentially number transmittal form. Revise submittals with original number and sequential alphabetic suffix.
- C. Prior to submittal, complete information under heading "Contractor's Transmittal."
- D. Owner will complete information under "Reviewer's Action."
- E. Do not include submittals for more than one section of Specifications on Submittal Transmittal form.
- F. Identify project title, location, and number and contract title and number.
- G. Identify preparer name and, submittal number, including preparer's submittal revision number.
- H. A brief description under "Title" should clearly identify specific application of equipment or material covered by Submittal, utilizing where possible same title used in Drawings and Specifications.
- I. Identify Specification Section number.

- J. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with requirements of Work and Contract Documents.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION





**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Quality control and control of installation.
- B. Building codes and permits.
- C. Welding certificates
- D. Examination.
- E. Preparation.
- F. Field performance tests.

1.02 QUALITY CONTROL AND CONTROL OF INSTALLATION

- A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
- B. Comply with manufacturers' instructions, including each step in sequence.
- C. Should manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.
- D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Perform Work by persons qualified to produce required and specified quality.
- F. Verify that field measurements are as indicated on Shop Drawings or as instructed by manufacturer.
- G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

1.03 BUILDING CODES AND PERMITS

- A. Obtain and pay for all construction permits and licenses. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses.
- B. Pay all governmental charges and inspection fees necessary for prosecution of Work, which are applicable at time of opening of Bids. Pay all charges of utility service companies for connections to Work. Owner will pay all charges of such companies for capital costs related thereto.
- C. Give all notices and comply with all laws, ordinances, building and construction codes, rules, and regulations applicable to Work. If Contractor observes that Specifications or Drawings are at variance therewith, give Engineer prompt written notice thereof, and any necessary changes shall be adjusted by appropriate Modification.
- D. If Contractor performs any Work knowing or having reason to know that it is contrary to such laws, ordinances, rules, and regulations, and without such notice to Owner, Contractor shall bear all costs arising from such work; however, it shall not be Contractor's primary responsibility to make certain that Specifications and Drawings are in accordance with such laws, ordinances, rules, and regulations.

## 1.04 REFERENCES

- A. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
- B. Conform to reference standard by date of issue current on date for receiving bids, except where a specific date is established by code.
- C. Obtain copies of standards where required by product specification sections.
- D. Should specified reference standards conflict with Contract Documents, request clarification from the Engineer before proceeding.
- E. Neither the contractual relationships, duties, or responsibilities of the parties in Contract nor those of the Engineer shall be altered from the Contract Documents by mention or inference otherwise in any reference document.
- F. Abbreviations used in Drawings and Specifications are as specified in ASME Y14.38 and IEEE 260.

## 1.05 WELDING CERTIFICATES

- A. Promptly after Notice of Award, submit to Engineer one copy, unless specified otherwise, for each person, by name, assigned to do field welding of materials installed under this Agreement.
- B. Show on certificates that each person has passed tests described in Specifications.
- C. Submit certificates prior to execution of any welding. Certificates not required for nonstructural tack welding.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

## 3.01 EXAMINATION

- A. Verify that existing site conditions and substrate surfaces are acceptable for subsequent Work. Beginning new Work means acceptance of existing conditions.
- B. Verify that existing substrate is capable of structural support or attachment of new Work being applied or attached.
- C. Examine and verify specific conditions described in individual specification sections.
- D. Verify that utility services are available, of the correct characteristics, and in the correct locations.

## 3.02 PREPARATION

- A. Clean substrate surfaces prior to applying next material or substance.
- B. Seal cracks or openings of substrate prior to applying next material or substance.
- C. Apply manufacturer required or recommended substrate primer, sealer, or conditioner prior to applying any new material or substance in contact or bond.

## 3.03 FIELD PERFORMANCE TESTS

- A. Notify Engineer when Work is considered to be complete, in operating condition, and ready for inspection and tests.
- B. Engineer will conduct tests it deems necessary to determine if equipment or system functions properly.
- C. If equipment or system fails to function properly, Contractor shall make necessary corrections, including replacement, at no cost to Owner, and after such corrections are completed, demonstrate to Engineer that equipment or system functions properly.
- D. If equipment or system fails to function properly, or guaranteed performance is not indicated, Contractor shall make necessary corrections, including replacement, at no cost to Owner, and after such corrections are completed, demonstrate to Engineer that equipment or system functions properly and guaranteed performance is obtainable.
- E. After system or equipment necessary for operation of Work is in operating condition, Contractor shall supervise operation of equipment or system for period sufficient to assure proper functioning, and make necessary observations, investigations, and adjustment.
- F. Notify Engineer when Work is considered to be complete, in operating condition, and ready for inspection and tests.
- G. Engineer will conduct tests it deems necessary to determine if equipment or system functions properly.
- H. If equipment or system fails to function properly, Contractor shall make necessary corrections, including replacement, at no cost to Owner, and after such corrections are completed, demonstrate to Engineer that equipment or system functions properly.
- I. If equipment or system fails to function properly, or guaranteed performance is not indicated, Contractor shall make necessary corrections, including replacement, at no cost to Owner, and after such corrections are completed, demonstrate to Engineer that equipment or system functions properly and guaranteed performance is obtainable.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Building codes and permits.
- B. Taxes.

1.02 BUILDING CODES AND PERMITS

- A. Contractor shall obtain and pay for all construction permits and licenses. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for prosecution of Work, which are applicable at time of opening of Bids. Contractor shall pay all charges of utility service companies for connections to Work, and Owner shall pay all charges of such companies for capital costs related thereto.
- B. Contractor shall give all notices and comply with all laws, ordinances, building and construction codes, rules, and regulations applicable to Work. If Contractor observes that Specifications or Drawings are at variance therewith, Contractor shall give Owner prompt written notice thereof, and any necessary changes shall be adjusted by appropriate Modification. If Contractor performs any Work knowing or having reason to know that it is contrary to such laws, ordinances, rules, and regulations, and without such notice to Owner, Contractor shall bear all costs arising therefrom; however, it shall not be Contractor's primary responsibility to make certain that Specifications and Drawings are in accordance with such laws, ordinances, rules, and regulations.

1.03 TAXES

- A. Contractor shall pay all sales, consumer, use and other similar taxes required to be paid by it in accordance with law of place of Project.
- B. After delivery to Site of items on which Contractor is required to pay such taxes.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Welding requirements.
- B. Procedure qualification.
- C. Performance qualification.

1.02 WELDING REQUIREMENTS

- A. Welding shall be performed by qualified welding operators using procedures which have been qualified in accordance with applicable codes and standards specified.

1.03 PROCEDURE QUALIFICATION

- A. Contractor, subcontractor, or fabricator performing welding under jurisdiction of referenced codes shall be responsible for obtaining and qualifying welding procedures. Structural welding procedures conforming to AWS D1.1 are prequalified as defined in AWS D1.1.
- B. Contractor shall maintain records, and make available to Owner when requested, certifying successful completion of procedure qualification tests.

1.04 PERFORMANCE QUALIFICATION

- A. Contractor, subcontractor, or fabricator performing welding under jurisdiction of referenced codes shall be responsible for testing and qualifying its welding operators in accordance with applicable procedures.
- B. Unless welding operators have been previously qualified by Contractor within last 6 months and have been continuously employed as welders by Contractor following qualification, requalification tests must be performed.
- C. Owner reserves right to require any welder to retake tests when, in opinion of Owner, work of welder creates reasonable doubt as to welder's proficiency; Owner reserves right to witness any required retesting; conduct such tests at no additional expense to Owner.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Costs.
- B. Materials.
- C. Toilet facilities.
- D. Installation.
- E. Maintenance, service.
- F. Removal.
- G. Cleaning.

1.02 COSTS

- A. Pay costs for installation, maintenance, and removal of temporary sanitary facilities.

**PART 2 PRODUCTS**

2.01 MATERIALS

- A. May be new or used, adequate to purpose, which will not create unsanitary conditions.

2.02 TOILET FACILITIES

- A. Enclosed portable self-contained units or temporary water closets and urinals, secluded from public view. Provide separate facilities for male and female personnel.

**PART 3 EXECUTION**

3.01 INSTALLATION

- A. Provide facilities at time of Site mobilization.

3.02 MAINTENANCE, SERVICE

- A. Clean areas of facilities daily, maintain in sanitary condition.
- B. Provide toilet paper, paper towels, and soap in suitable dispensers.

3.03 REMOVAL

- A. Remove portable units upon completion of project.

3.04 CLEANING

- A. Restore existing and permanent areas and facilities used to original condition.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Enclosures and fences.
- B. Vehicular access.
- C. Construction parking controls.
- D. Protection of surfaces.
- E. Haul routes.
- F. Removal.

1.02 GENERAL REQUIREMENTS

- A. Contractor is solely responsible to make sure barricades are placed at excavation site when not in attendance or where safety of motorist is of concern while Work is proceeding.
- B. Provide lighting of barricades on construction sites as necessary.

**PART 2 PRODUCTS**

2.01 ENCLOSURES AND FENCES

- A. Barrier fences: 10' high, removable chain link construction fences. Contractor shall be responsible for temporary fence installation approved by Owner prior to use.
- B. Construction fence: 4' high, construction safety fence, steel posts, orange in color. Materials, locations, and installations will be approved by Owner.

**PART 3 EXECUTION**

3.01 VEHICULAR ACCESS

- A. Location as indicated by Owner.
- B. Provide unimpeded access for emergency vehicles. Maintain 20' (6 m) width driveways with turning space between and around combustible materials.
- C. Provide and maintain access to fire hydrants and control valves free of obstructions.
- D. Provide means of removing mud from vehicle wheels before entering streets.
- E. Designated existing on-site roads may be used for construction traffic.

3.02 CONSTRUCTION PARKING

- A. Prevent parking on or adjacent to access roads or in non-designated areas.
- B. Locate as indicated and approved by Owner.
- C. Use of existing on-site streets and driveways used for construction traffic is not permitted.

- D. Use of designated areas of existing parking facilities used by Owner personnel is not permitted.
- E. Repair:
  - 1. Repair existing and permanent facilities damaged by use, to like new condition.
- F. Mud from site vehicles: Provide means of removing mud from vehicle wheels before entering streets.

### 3.03 PROTECTION OF STREET SURFACES

- A. Traveled portion of permanent and temporary surfaces and structures on or adjacent to Work site shall be protected from damage by lugs or cleats on treads or wheels of equipment. When crossing or working upon such surfaces with equipment with lugs or cleats, place timber or rubber pads under lugs or cleats to prevent damage to surfaces.
- B. Equipment used in prosecution of Work shall comply with legal loading limits established by statutes of local regulations when moved or operated on any traveled surface or structure unless permission in writing has been issued by Owner. Before using any equipment which may exceed legal loading, secure necessary permits, allowing ample time for making an analysis of stresses to determine whether or not proposed loading would be within safe limits.
- C. Owner will not be responsible for any delay in construction, in operations or for any costs incurred by Contractor as a result of compliance or noncompliance with above requirements. Contractor shall repair and/or replace at its own expense, pavement damage as a result of its failure to comply with above requirements, and moneys due may be withheld to cover such damage. Owner will determine extent of damages and cost of replacement.

### 3.04 HAUL ROUTES

- A. Consult with authority having jurisdiction, establish public thoroughfares to be used for haul routes and site access. Determine haul roads with approval of agency having jurisdiction over proposed roadway.
- B. Confine construction traffic to designated haul routes.
- C. Provide traffic control at critical areas of haul routes to regulate traffic, to minimize interference with public traffic.
- D. Make condition survey of haul roads prior to use and document with necessary photographs and written descriptions.
- E. Keep reasonably free from dirt, dust, mud, and other debris from construction operations.
- F. Clean a minimum of twice a week.
- G. Repair damaged haul routes to match existing conditions before use.

### 3.05 REMOVAL

- A. Remove temporary equipment, facilities, and materials when no longer required.
- B. Clean and repair damage caused by installation or use of temporary work.
- C. Restore existing and permanent facilities used during construction to original condition.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Products.
- B. Product delivery requirements.
- C. Receiving, unloading, and storing at Site.
- D. General storage.
- E. Enclosed storage.
- F. Exterior storage.
- G. Maintenance of storage.
- H. Maintenance of equipment storage.
- I. Product options.

1.02 PRODUCTS

- A. Provide products of qualified manufacturers suitable for intended use. Provide products of each type by a single manufacturer unless specified otherwise.
- B. Do not use materials and equipment removed from existing premises, except as specifically permitted by the Contract Documents.
- C. Provide interchangeable components of the same manufacturer for components being replaced.

1.03 PRODUCT DELIVERY REQUIREMENTS

- A. Transport and handle products in accordance with manufacturer's instructions.
- B. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.
- C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.04 RECEIVING, UNLOADING AND STORING

- A. Receive and unload shipments to plant site from suppliers of equipment under this Contract.
- B. Unload equipment as soon as possible after arrival.
- C. Pay freight car and truck demurrage, detention, and any other costs which may be billed to Owner due to failure to unload cars or trucks within time required by freight companies.
- D. Provide physical protection for equipment placed in storage.
  - 1. Store and maintain materials and equipment after receipt until completed installation is accepted by Owner. Such storage and maintenance shall be in accordance with manufacturer's recommendations and requirements of these Specifications. Provide materials, equipment, and

- labor required for such storage and maintenance. Contractor shall be accountable for any deterioration of materials or equipment occasioned by improper storage or maintenance, and shall recondition, repair, or replace any such materials or equipment without addition cost to Owner.
2. Stored equipment shall be supported above ground and shall be covered with canvas or other heavy-duty sheeting. Cover shall be securely fastened and shall be replaced if torn or otherwise damaged during storage period.
- E. Inspect stored equipment weekly. Renew protective coatings as necessary to preserve fitness of equipment.
  - F. Contractor shall take custody of equipment and materials received and shall be solely responsible for damage and shortages until acceptance of Contractor's work by Owner.
  - G. Unload equipment as soon as possible after arrival. Contractor shall pay freight railcar and truck demurrage, detention, and any other costs which may be billed to Owner due to failure to unload railcars or trucks within time required by freight companies.
  - H. Use of bare wire rope slings for unloading and handling equipment and materials is prohibited without Owner approval.
  - I. Storage areas will be allocated by Owner for Contractor's use. Equipment shall be stored in assigned lay-down areas.
  - J. Equipment and materials shall be stored and maintained in accordance with manufacturer's recommendations and these specifications.
  - K. Contractor shall provide materials, equipment, and labor required for such storage and maintenance. Contractor shall be accountable for any deterioration of materials or equipment occasioned by improper storage or maintenance, and shall recondition, repair, or replace any such materials or equipment without additional cost to Owner.

#### 1.05 GENERAL STORAGE

- A. Store products immediately on delivery in accordance with manufacturer's instructions, with seals and labels intact. Protect until installed.
- B. Arrange storage in manner to provide access for maintenance of stored items and for inspection.

#### 1.06 ENCLOSED STORAGE

- A. Store products subject to damage by elements in substantial weathertight enclosures.
- B. Maintain temperature and humidity within ranges required by manufacturer's instructions.
- C. Provide humidity control and ventilation for sensitive products, as required by manufacturer's instructions.
- D. Store unpacked and loose products on shelves, in bins, or in neat groups of like items.

#### 1.07 EXTERIOR STORAGE

- A. Provide substantial platforms, blocking, or skids, to support fabricated products above ground; slope to provide drainage. Protect products from soiling and staining.
- B. For products subject to discoloration or deterioration from exposure to elements, cover with impervious sheet material. Provide ventilation to avoid condensation.

- C. Store loose granular materials on clean, solid surfaces such as pavement, or on rigid sheet materials, to prevent mixing with foreign matter.
- D. Provide surface drainage to prevent flow or ponding of rainwater.
- E. Prevent mixing of refuse or chemically injurious materials or liquids.

#### 1.08 MAINTENANCE OF STORAGE

- A. Periodically inspect stored products on scheduled basis.
- B. Verify storage facilities comply with manufacturer's product storage requirements.
- C. Verify manufacturer required environmental conditions are maintained continually.
- D. Verify surfaces of products exposed to elements are not adversely affected and if weathering of finishes is acceptable under requirements of Contract Documents.

#### 1.09 MAINTENANCE OF EQUIPMENT STORAGE

- A. For mechanical and electrical equipment in long-term storage, manufacturer's service instructions shall accompany each item, with notice of enclosed instructions shown on exterior of package.
- B. Service equipment on regularly scheduled basis, maintaining log of services; submit as record document.

#### 1.10 PRODUCT OPTIONS

- A. For products specified only by reference standard, select product meeting that standard, by any manufacturer.
- B. For products specified by naming several products or manufacturers, select any one of products and manufacturers named which complies with Specifications.
- C. For products specified by naming only one product and manufacturer, there is no option and no substitution will be allowed.
- D. Whenever Specifications call for item by manufacturer's name and type and additional features of item are specifically required by Specifications, additional features specified shall be provided whether or not they are normally included in standard manufacturer's item listed.

### **PART 2 PRODUCTS**

NOT USED

### **PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Closeout procedures.
- B. Final cleaning.
- C. Protecting installed construction.
- D. Project record documents.
- E. Manual for materials and finishes.
- F. Product warranties and product bonds.

1.02 CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for Engineer's review.
- B. Provide submittals to Engineer that are required by governing or other authorities.
- C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

1.03 FINAL CLEANING

- A. Owner will provide final cleaning after final acceptance.
- B. Execute final cleaning prior to final project assessment.
- C. Clean site; sweep paved areas.
- D. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.04 PROTECTING INSTALLED CONSTRUCTION

- A. Protect installed Work and provide special protection where specified in individual specification sections.
- B. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.

1.05 PROJECT RECORD DOCUMENTS

- A. Maintain on site one set of the following record documents; record actual revisions to the Work:
  - 1. Drawings.
  - 2. Specifications.
  - 3. Addenda.
  - 4. Change Orders and other modifications to the Contract.
  - 5. Reviewed Shop Drawings, Product Data, and Samples.
  - 6. Manufacturer's instruction for assembly, installation, and adjusting.
- B. Ensure entries are complete and accurate, enabling future reference by Owner.

- C. Store record documents separate from documents used for construction.
- D. Record information concurrent with construction progress, not less than weekly.
- E. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:
  - 1. Manufacturer's name and product model and number.
  - 2. Product substitutions or alternates utilized.
  - 3. Changes made by Addenda and modifications.
- F. Record Drawings and Shop Drawings: Legibly mark each item to record actual construction including:
  - 1. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - 2. Field changes of dimension and detail.
  - 3. Details not on original Contract Drawings.
- G. Submit documents to Owner with claim for final Application for Payment.

#### 1.06 MANUAL FOR MATERIALS AND FINISHES

- A. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. Engineer will review draft and return one copy with comments.
- B. Submit one copy of completed volumes 7 days prior to final inspection. This copy will be reviewed and returned after final inspection, with Engineer comments. Revise content of all document sets as required prior to final submission.
- C. Submit 2 sets of revised final volumes in final form within 5 days after final inspection.
- D. Applied materials and finishes: Include product data, with catalog number, size, composition, and color and texture designations.
- E. Moisture protection and weather exposed products: Include product data listing applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair.
- F. Additional requirements: As specified in individual product specification sections.
- G. Provide a listing in Table of Contents for design data, with tabbed fly sheet and space for insertion of data.

#### 1.07 PRODUCT WARRANTIES AND PRODUCT BONDS

- A. Obtain warranties and bonds executed in duplicate by responsible subcontractors, suppliers, and manufacturers, within ten days after completion of the applicable item of work.
- B. Execute and assemble transferable warranty documents and bonds from subcontractors, suppliers, and manufacturers.
- C. Verify that documents are in proper form, contain full information, and are notarized.
- D. Co-execute submittals when required.
- E. Submit prior to final Application for Payment.
- F. Time of Submittals:

1. For equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within 10 days after acceptance.
2. Make other submittals within 10 days after Date of Substantial Completion, prior to final Application for Payment.
3. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit within 10 days after acceptance, listing the date of acceptance as the beginning of the warranty or bond period.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Cutting and patching requirements.
- B. Materials.
- C. Inspection.
- D. Preparation.
- E. Performance.

1.02 CUTTING AND PATCHING REQUIREMENTS

- A. Contractor shall be responsible for cutting, fitting, and patching, including attendant excavation and backfill, required to complete Work or to:
  - 1. Make its several parts fit together properly.
  - 2. Uncover portions of Work to provide for installation of ill-timed Work.
  - 3. Remove and replace defective Work.
  - 4. Remove and replace Work not conforming to requirements of Contract Documents.
  - 5. Remove samples of installed Work as specified for testing.
  - 6. Provide routine penetrations of nonstructural surfaces for installation of piping and electrical conduit.

1.03 SUBMITTALS

- A. Submit written request to Owner well in advance of executing cutting or alteration which affects:
  - 1. Work of Owner or any separate contractor.
  - 2. Structural value or integrity of any element of Project.
  - 3. Integrity or effectiveness of weather-exposed or moisture-resistant elements or systems.
  - 4. Efficiency, operational life, maintenance, or safety of operational elements.
  - 5. Visual qualities of sight-exposed elements.
- B. Request shall include:
  - 1. Identification of Project.
  - 2. Description of affected Work.
  - 3. Necessity for cutting, alteration, or excavation.
  - 4. Effect on work of Owner or separate contractor, or structural or weatherproof integrity of Project.
  - 5. Description of proposed Work:
    - a. Scope of cutting, patching, alteration, or excavation.
    - b. Trades who will execute Work.
    - c. Products proposed to be used.
    - d. Extent of refinishing to be done.
  - 6. Alternatives to cutting and patching.
  - 7. Cost proposal, when applicable.
  - 8. Written permission of any separate Contractor whose work will be affected.
- C. Should conditions of Work or schedule indicate change of products from original installation, Contractor shall submit request for substitution.
- D. No cutting or alteration for which written request is submitted shall be performed without written acceptance of Engineer.
- E. Submit written notice to Engineer designating date and time Work will be uncovered.

**PART 2 PRODUCTS**

2.01 MATERIALS

- A. Comply with specifications and standards for each specific product involved.

**PART 3 EXECUTION**

3.01 INSPECTION

- A. Inspect existing conditions of Project, including elements subject to damage or to movement during cutting and patching.
- B. After uncovering Work, inspect conditions affecting installation of products, or performance of Work.
- C. Report unsatisfactory or questionable conditions to Engineer in writing; do not proceed with Work until Engineer has provided further instructions.

3.02 PREPARATION

- A. Provide adequate temporary support as necessary to assure structural value or integrity of affected portion of Work.
- B. Provide devices and methods to protect other portions of Project from damage.
- C. Provide protection from elements for that portion of Project which may be exposed by cutting and patching Work, and maintain excavations free from water.

3.03 PERFORMANCE

- A. Execute cutting and demolition by method which will prevent damage to other Work, and will provide proper surfaces to receive installation of repairs.
- B. Execute excavating and backfilling by methods which will prevent settlement or damage to other Work.
- C. Employ original installer or fabricator to perform cutting and patching for:
  - 1. Weather-exposed or moisture-resistant elements.
  - 2. Sight-exposed finished surfaces.
- D. Execute fitting and adjustment of products to provide finished installation to comply with specified products, functions, tolerances, and finishes.
- E. Restore Work which has been cut or removed; install new products to provide completed Work in accordance with requirements of Contract Documents.
- F. Fit Work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- G. Refinish entire surfaces as necessary to provide even finish to match adjacent finishes:
  - 1. For continuous surfaces, refinish to nearest intersection.
  - 2. For assembly, refinish entire unit.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Disposal requirements.
- B. Materials.
- C. Cleaning during construction.
- D. Final cleaning.

1.02 DISPOSAL REQUIREMENTS

- A. Conduct cleaning and disposal requirements to comply with codes, ordinances, regulations, and anti-pollution laws.

**PART 2 PRODUCTS**

2.01 MATERIALS

- A. Use only those cleaning materials which will not create hazards to health or property and which will not damage surfaces.
- B. Use only those cleaning materials and methods recommended by manufacturer of surface material to be cleaned.
- C. Use cleaning materials only on surface recommended by cleaning material manufacturer.

**PART 3 EXECUTION**

3.01 CLEANING DURING CONSTRUCTION

- A. Execute periodic cleaning to keep Work, site, and adjacent properties free from accumulations of waste materials, rubbish, and windblown debris, resulting from construction operations.
- B. Provide on-site containers for collection waste materials, debris, and rubbish.
- C. Remove waste materials, debris, and rubbish from site periodically and dispose of at legal disposal areas away from site.
- D. Dispose of waste materials, debris and rubbish at designated dumping area on Owner's property.

3.02 FINAL CLEANING

- A. Employ skilled workers for final cleaning.
- B. Remove foreign materials, all tools, appliances, construction equipment and machinery, and surplus materials.
- C. Broom clean exterior paved surfaces; rake clean other surfaces of the grounds, so as to leave site ready for occupancy by Owner, and restore those portions of site not designated for alteration by Contract Documents to their condition as of beginning of Work.

- D. Prior to final completion, or Owner occupancy, Contractor shall conduct inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that entire Work is clean.
- E. Contractor shall broom clean exterior paved surfaces; rake clean other surfaces of the grounds, so as to leave site ready for occupancy by Owner, and restore those portions of site not designated for alteration by Contract Documents to their condition as of beginning of Work.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Substantial completion.
- B. Final completion.
- C. Closeout submittals.
- D. Adjustment of accounts.
- E. Application for final payment.

1.02 SUBSTANTIAL COMPLETION

- A. When the Contractor considers the Work is substantially complete, submit written notice, with list of items to be completed or corrected.
- B. Within reasonable time, Engineer will inspect to determine status of completion.
- C. Should Engineer determine that Work is not substantially complete, it will promptly notify Contractor in writing, giving reasons therefor.
- D. Contractor shall remedy deficiencies, and send second written notice of substantial completion, and Engineer will reinspect Work.
- E. When Engineer determines that Work is substantially complete, it will prepare Certificate of Substantial Completion in accordance with General Conditions.

1.03 FINAL COMPLETION

- A. When the Contractor considers the Work is complete, it shall submit written certification that:
  - 1. Contract Documents have been reviewed.
  - 2. Work has been inspected for compliance with Contract Documents.
  - 3. Work has been completed in accordance with Contract Documents, and deficiencies listed with Certificate of Substantial Completion have been corrected.
  - 4. Equipment and systems have been tested in presence of Owner's representative and are operational.
  - 5. Work is complete and ready for final inspection.
- B. Owner will inspect to verify status of completion with reasonable promptness.
- C. Should Engineer consider that Work is incomplete or defective, it will promptly notify Contractor in writing, listing incomplete or defective Work.
- D. Contractor shall take immediate steps to remedy deficiencies and send second written certification that Work is complete, and Owner will reinspect Work.
- E. When Owner finds Work is acceptable, it will consider closeout submittals.

1.04 REINSPECTION FEES

- A. Should Owner perform re-inspections due to failure of Work to comply with claims made by Contractor, Owner will deduct amount of such compensation from final payment to Contractor.

1.05 CLOSEOUT SUBMITTALS

- A. Evidence of compliance with requirements of governing authorities:
- B. Certificates of inspection:
  - 1. Mechanical.
  - 2. Cathodic Protection
- C. Project record documents: In accordance with Section 01 78 00.
- D. Operation and maintenance data, instructions to Owner's personnel: In accordance with Section 01 78 23.
- E. Warranties and Bonds: In accordance with Section 01 78 00.
- F. Evidence of payment and release of liens: In accordance with General and Supplementary Conditions.
- G. Consent of Surety to final payment.
- H. Certificates of insurance for products and completed operations: In accordance with Supplementary Conditions.

#### 1.06 ADJUSTMENT OF ACCOUNTS

- A. Submit final statement of accounting, reflecting adjustments to Contract Price:
- B. Original Contract Price.
- C. Additions and deductions resulting from:
  - 1. Previous Change Orders.
  - 2. Allowances.
  - 3. Unit prices.
  - 4. Deductions for uncorrected Work.
  - 5. Penalties and bonuses.
  - 6. Deductions for liquidated damages.
  - 7. Deductions for reinspection payments.
  - 8. Other adjustments.
- D. Total Contract Price, as adjusted.
- E. Previous payments.
- F. Sum remaining due.
- G. Owner will issue final Change Order, reflecting approved adjustments to Contract Price not previously made by Change Orders.

#### 1.07 APPLICATION FOR FINAL PAYMENT

- A. Submit Application for Final Payment in accordance with procedures and requirements in conditions of Agreement.

### **PART 2 PRODUCTS**

NOT USED

### **PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Maintenance of documents and samples.
- B. Marking devices.
- C. Recording.
- D. Submittal.

1.02 MAINTENANCE OF DOCUMENTS AND SAMPLES

- A. Maintain at Site for Owner one record copy of:
  - 1. Drawings.
  - 2. Specifications.
  - 3. Addenda.
  - 4. Change Orders and other Modifications to Agreement.
  - 5. Owner Instruction to Contractor or written instructions.
  - 6. Reviewed Shop Drawings and Samples.
  - 7. Field test records.
- B. Store documents and Samples in Contractor's field office apart from documents used for construction.
  - 1. Provide files and racks for storage of documents.
- C. File documents and Samples in accordance with Construction Specifications Institute (CSI) format.
- D. Maintain documents in clean, dry, legible condition and in good order. Do not use record documents for construction purposes.
- E. Make documents and Samples available at all times for reference by Owner.

1.03 MARKING DEVICES

- A. Provide felt tip marking pens for recording information in color code designated by Owner.

1.04 RECORDING

- A. Label each document "PROJECT RECORD" in neat large printed letters.
- B. Record information concurrently with construction progress. Do not conceal any Work until required information is recorded.
- C. Drawings shall be legibly marked to record actual construction:
  - 1. Depths of various elements of foundation in relation to finish first floor datum.
  - 2. Horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - 3. Location of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of structure.
  - 4. Field changes of dimension and detail.
  - 5. Changes made by Instruction to Contractor or by Change Order.
  - 6. Details not on original contract Drawings.
- D. Specifications and Addenda shall be legibly marked to record:

1. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
2. Changes made by Instruction to Contractor or by Change Order.

1.05 SUBMITTAL

- A. At Agreement close-out, deliver record documents to Owner.
- B. Accompany submittal with transmittal letter in duplicate, containing:
  1. Date.
  2. Project title and number.
  3. Contractor's name and address.
  4. Title and number of each record document.
  5. Signature of Contractor or its authorized representative.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Operating and maintenance data requirements.
- B. Quality assurance.
- C. Form of submittals.
- D. Content of manual.
- E. Manual for materials and finishes.
- F. Manual for equipment and systems.
- G. Submittal schedule.
- H. Instruction of Owner's personnel.

1.02 OPERATING AND MAINTENANCE DATA REQUIREMENTS

- A. Operating and maintenance data shall be in English language.
- B. Compile product data and related information appropriate for Owner's maintenance and operation of products furnished under Agreement.
- C. Prepare operating and maintenance data as specified in this section and as referenced in other pertinent sections of Specifications.
- D. Instruct Owner's personnel in maintenance of products and in operation of equipment and systems.

1.03 QUALITY ASSURANCE

- A. Preparation of data shall be done by personnel:
  - 1. Trained and experienced in maintenance and operation of described products.
  - 2. Familiar with requirements of this section.
  - 3. Skilled as technical writers to extent required to communicate essential data.
  - 4. Skilled as draftsmen competent to prepare required drawings.

1.04 FORM OF SUBMITTALS

- A. Prepare data in form of an instructional manual for use by Owner's personnel.
- B. Format: Electronic CDs, pdf format documents or:
  - 1. Sheet size: 8-1/2" x 11" minimum.
  - 2. Paper: 20 lb minimum, white, for typed pages.
  - 3. Text: Manufacturer's printed data, or neatly typewritten.
  - 4. Drawings:
    - a. Provide reinforced punched binder tab, bind in with text.
    - b. Larger size drawings shall be folded to 8-1/2" x 11", and inserted into pockets.
  - 5. Provide fly-leaf for each separate product, or each piece of operating equipment.
    - a. Provide typed description of product, and major component parts of equipment.
    - b. Provide indexed tabs.
  - 6. Cover: Identify each volume with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS." List:

- a. Title of Project.
  - b. Identity of separate structure as applicable.
  - c. Identity of general subject matter covered in manual.
7. Binders:
- a. Commercial quality 3-ring binders with durable and cleanable plastic covers.
  - b. Maximum ring size: 1".
  - c. When multiple binders are used, correlate data into related consistent groupings.

#### 1.05 CONTENT OF MANUAL

- A. Neatly typewritten table of contents for each volume, arranged in systematic order.
1. Contractor, name of responsible principal, address, and telephone number.
  2. List of each product required to be included, indexed to content of volume.
  3. List, with each product, name, address, and telephone number of:
    - a. Subcontractor or installer.
    - b. Maintenance contractor, as appropriate.
    - c. Identify area of responsibility of each.
    - d. Local source of supply for parts and replacement and list of recommended spare parts.
  4. Identify each product by product name and other identifying symbols as set forth in Contract Documents, including nameplate information and shop order numbers for each item of equipment furnished.
- B. Product data:
1. Include only those sheets which are pertinent to specific product.
  2. Annotate each sheet to:
    - a. Clearly identify specific product or part installed.
    - b. Clearly identify data applicable to installation.
    - c. Delete references to inapplicable information.
- C. Drawings:
1. Supplement product data with Drawings as necessary to clearly illustrate:
    - a. Relations of component parts of equipment and systems.
    - b. Control and flow diagrams.
  2. Coordinate Drawings with information in Project record documents to assure correct illustration of completed installation.
  3. Do not use Project record documents as maintenance Drawings.
- D. Written text, as required to supplement product data for particular installation.
1. Organize in consistent format under separate headings for different procedures.
  2. Provide logical sequence of instructions for each procedure.
- E. Copy of each warranty, Bond, and service contract issued.
1. Provide information sheet for Owner's personnel, giving:
    - a. Proper procedures in event of failure.
    - b. Instances which might affect validity of warranties or Bonds.

#### 1.06 MANUAL FOR MATERIALS AND FINISHES

- A. Submit 3 copies of complete manual in final form.
- B. Contents, for architectural products, applied materials and finishes:
1. Manufacturer's data, giving full information on products.
    - a. Catalog number, size, composition.
    - b. Color and texture designations.
    - c. Information required for re-ordering special-manufactured products.
- C. Contents, for moisture protection and weather-exposed products:

1. Manufacturer's data, giving full information on products.
  - a. Applicable standards.
  - b. Chemical composition.
  - c. Details of installation.
2. Instructions for inspection, maintenance, and repair.

D. Additional requirements for maintenance data: Respective sections of Specifications.

## 1.07 MANUAL FOR EQUIPMENT AND SYSTEMS

A. Submit 3 copies of complete manual in final form

B. Contents, for each unit of equipment and system, as appropriate:

1. Description of unit and component parts:
  - a. Function, normal operating characteristics, and limiting conditions.
  - b. Performance curves, engineering data, and tests.
  - c. Complete nomenclature and commercial number of replaceable parts.
2. Operating procedures:
  - a. Startup, break-in, routine, and normal operating instructions.
  - b. Regulation, control, stopping, shutdown, and emergency instructions.
  - c. Summer and winter operating instructions.
  - d. Special operating instructions.
3. Maintenance procedures:
  - a. Routine operations.
  - b. Guide to "trouble-shooting."
  - c. Disassembly, repair, and reassembly.
  - d. Alignment, adjusting, and checking.
4. Servicing and lubrication schedule: List of lubricants required.
5. Manufacturer's printed operating and maintenance instructions.
6. Description of sequence of operation by control manufacturer.
7. Original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
  - a. Predicted life of parts subject to wear.
  - b. Items recommended to be stocked as spare parts.
8. As-installed control diagrams by controls manufacturer.
9. Each contractor's coordination Drawings. As-installed color-coded piping diagrams.
10. Chart of valve tag numbers, with location and function of each valve.
11. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
12. Other data as required under pertinent sections of Specifications.

C. Content, for each electrical and electronic system, as appropriate.

1. Description of system and component parts:
  - a. Function, normal operating characteristics, and limiting conditions.
  - b. Performance curves, engineering data, and tests.
  - c. Complete nomenclature and commercial number of replacement parts.
2. Circuit directories of panelboards:
  - a. Electrical service.
  - b. Controls.
  - c. Communications.
3. As-installed color-coded wiring diagrams.
4. Operating procedures:
  - a. Routine and normal operating instructions.
  - b. Sequences required.
  - c. Special operating instructions.
5. Maintenance procedures:
  - a. Routine operations.

- b. Guide to "trouble-shooting."
  - c. Disassembly, repair, and assembly.
  - d. Adjustment and checking.
  - 6. Manufacturer's printed operating and maintenance instructions.
  - 7. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
  - 8. Other data as required under pertinent sections of Specifications.
- D. Prepare and include additional data when need for such data becomes apparent during instruction of Owner's personnel.
- E. Additional requirements for operating and maintenance data: Respective sections of Specifications.

1.08 SUBMITTAL SCHEDULE

- A. Preliminary draft:
- 1. Provide 2 copies with shipped with equipment.
  - 2. Submit 2 copies to Owner of proposed formats and outlines of contents prior to start of Work. Owner will review draft and return 1 copy with comments.
- B. Submit 1 copy of completed data in final form 15 days prior to final inspection or acceptance. Copy will be returned after final inspection or acceptance, with comments.
- C. Submit specified copies of approved data in final form 10 days after final inspection or acceptance.

1.09 DEMONSTRATION AND INSTRUCTION OF OWNER'S PERSONNEL

- A. Demonstrate operation and maintenance of products to Owner's personnel 2 weeks prior to date of final inspection.
- B. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner's personnel in detail to explain all aspects of operation and maintenance.
- C. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at agreed time at designated location.
- D. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- E. Amount of time required for instruction on each item of equipment and system is that specified in individual sections.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

NOT USED

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Removal and disposal of existing mechanical and electrical equipment and associated work.
- B. Demolition work of this contract includes, but is not limited to:
  - 1. **Removal of existing Heat Recovery Unit: HR-N.**
  - 2. **Removal of the electrical equipment and controls associated with HR-N.**
  - 3. **Removal of existing ductwork, VAV boxes, dual duct boxes, and ductwork accessories.**
  - 4. **Removal of existing fan coil units and accessories.**
  - 5. **Removal of existing exhaust fans, exhaust ducts, and accessories.**
  - 6. **Removal of existing mechanical piping.**
  - 7. **Removal of existing controls associated with above equipment.**
  - 8. **Removal of existing electrical equipment associated with above equipment.**
  - 9. **Removal of existing ceiling tiles.**
- C. Inspect buildings and structures where demolition is required. Contractor shall also inspect existing Drawings of buildings and structures before bidding; Drawings are available from Owner. Contractor shall be familiar with items that require demolition and patching.
- D. Contractor is responsible for determining actual site conditions, extent to which demolition is required, and method of demolition.
- E. Perform work in accordance with Drawings and Specifications and as required for proper execution of work under this Contract.

1.02 WORK BY OTHERS

- A. Owner will remove, salvage, or relocate the following:
  - 1. \_\_\_\_\_.
  - 2. \_\_\_\_\_.
  - 3. \_\_\_\_\_.

1.03 SALVAGEABLE ITEMS

- A. Following equipment shall be removed and remain property of Owner. Contractor shall remove salvageable equipment and transport to Owner's designated storage area located at enclosed utility yard.
- B. Salvageable equipment list:
  - 1. \_\_\_\_\_.
  - 2. \_\_\_\_\_.
  - 3. \_\_\_\_\_.
- C. Tag salvageable items and submit list to Owner identifying equipment and tag numbers.
- D. Upon delivery of a salvaged item to designated storage area, Contractor shall receive from Owner receipt indicating delivery of that item.

1.04 QUALITY ASSURANCE

- A. Temporary electrical construction necessary to maintain existing system during construction shall comply with NEC Article 590.

## 1.05 SUBMITTALS

- A. Two weeks prior to any removal, Contractor shall submit demolition plan to Engineer for review. Plans shall include sequence of performing proposed work, requirements for interruptions to public use of area, and requirements for Contractor use of public streets and facilities.
- B. Submit 1 copy of photographs taken of existing construction to remain. Include adjacent private properties that might be disturbed by demolition operations.

## 1.06 SITE CONDITIONS

- A. Known piping and other concluded obstructions in vicinity of new construction are shown on Drawings.
- B. Notify Engineer and Owner of unexpected conditions and discontinue Work in area until Owner provides notification to resume Work.

## 1.07 SCHEDULING

- A. Perform Work in manner which will provide least interference and most protection to public and existing construction. Contractor's operations subject to approval by Owner prior to commencement of Work.
- B. Carefully coordinate time and manner of demolition work with Engineer to assure continued operation of existing facilities and to maintain construction schedule requirements.
- C. Schedule and perform work in accordance with following general sequence. Coordinate specific details of work with Owner and Contract. Owner's use of premises shall have priority over work in all Contract(s).
- D. Take care to minimize outages of mechanical and electrical systems.
- E. Coordinate electrical system outages with Owner and service utility. Notify Owner in writing at least 24 hours prior to electrical outage. Indicate system to be disabled, areas affected, proposed date and time of outage, duration, and work to be performed.
- F. Outages of following electrical systems shall be performed only with written permission of Owner.
  - 1. **Power distribution.**
  - 2. **Fire alarm.**
  - 3. **Telephone.**
  - 4. **Mechanical systems and controls.**

## 1.08 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment will be made for demolition work under this contract except as specifically described and listed in Agreement. Include costs in connection with Work in lump sum Contract Price or unit price for demolition.
- B. Measurement for payment for any undefined demolition will be performed by Contractor and verified by Engineer during removal of material.

**PART 2 PRODUCTS**

NOT USED

**PART 3 EXECUTION**

## 3.01 PROTECTION

- A. Protect existing facilities from damage by falling debris, dust, and construction operations.

- B. Provide shoring and bracing where necessary to support existing construction and protect personnel during demolition operation.

### 3.02 DEMOLITION - GENERAL

- A. Remove existing construction as specified and shown and as required to permit new construction.
- B. Perform removal in manner that will minimize dust, noise, and other nuisance. Maintain haul routes for disposal of material clean and free of debris.
- C. Remove existing construction carefully providing for neat and orderly junctions at construction to remain in place. Final appearance of exposed surfaces shall be similar and equal to that of adjacent existing work. Grind off rough surfaces to remove sharp projections.
- D. Perform demolition operations in manner that in no way endangers personnel, public, existing structures, utilities, roadways, or facilities not to be demolished.
- E. Any portion of existing construction whether structural, or accessory which has become unstable through removal of other parts of construction shall be removed as soon as practicable, and no such unstable part shall be left free-standing or inadequately braced against causes of collapse at end of each day's work.
- F. No demolition shall be performed on piping, electrical circuits, or equipment until system has been isolated by Owner. Contractor shall verify isolation of system.
- G. Contractor shall relocate existing active miscellaneous piping, conduit, and electrical circuits and devices not detailed on Drawings but required for installation of equipment and items installed by this Contract.
- H. To reduce fire hazards during demolition, Contractor shall:
  - 1. **Maintain sufficient number of fire extinguishers to check and extinguish small fires in areas where Work is being performed.**
  - 2. **Wherever cutting torch or other equipment which might cause fire is being used, fire extinguishers shall be kept nearby and ready for instant use. Users of such equipment shall be instructed in proper method of preventing fires and extinguishing fire.**
  - 3. **Fires will not be permitted in Project area.**
- I. Use of cranes for demolition work are permitted as long as following conditions are met:
  - 1. **Machinery, cables, booms, and other equipment shall pass applicable safety inspections.**
  - 2. **Crane boom may not be used within 20' of overhead power lines.**
  - 3. **Demolition work shall not cause debris to be kicked outward away from demolition area.**
  - 4. **Operations do not damage adjacent construction.**
- J. Use of blasting will not be permitted.
- K. Provide temporary personnel and vehicle protection at openings or ledges made by demolition.

### 3.03 DEMOLITION OF ARCHITECTURAL, STRUCTURAL, AND SITE MATERIALS

- A. Remove as shown and specified or as required to permit new construction.
- B. Structural parts of buildings, such as columns, beams, and joists supporting floor of any story shall be left in place until walls, flooring, and partitions of that story are completely removed, beginning at top and working downward. Exception to this requirement will be made in case of nonrigid frames or concrete buildings.

- C. If Contractor elects to use an alternate procedure for progressive or simultaneous wrecking of all parts of building, Contractor's proposed method shall not increase danger to Contractor's personnel, Owner's personnel, or to adjacent structures. Contractor shall notify Owner in writing of any such alternate procedure proposed before implementing such procedures.
- D. No wall or part thereof shall be permitted to fall outwardly from any building or into plant basement or floor except through chutes or by other controlled means or methods which will ensure safety and minimize dust, noise, and other nuisance.
- E. Any part of building, whether structural, or accessory, which has become unstable through removal of other parts shall be removed as soon as practicable, and no such unstable part shall be left free-standing or inadequately braced against cause of collapse at end of day's work.
- F. Structural steel in building:
1. **Provide temporary support or complete new work required for support prior to removal. Maintain existing parts until equipment supported by part is removed or modified.**
  2. **Remove and dispose of steel indicated on Drawings including miscellaneous associated steel. Do not remove bolts and/or rivets of common connections; cut member being removed to leave connection unless shown otherwise.**
  3. **Where steel penetrates masonry or concrete wall, cut flush with wall unless shown otherwise.**
  4. **Where applicable, remove anchor bolts and grout to top or face of existing concrete. Make provisions to ensure smooth surface where grout is removed.**
  5. **Care shall be taken not to damage any portion of existing structural steel that is to remain intact.**
- G. Material shall be removed completely from roof, building, grounds, and other areas which are to remain. Contractor shall make special inspections by its job superintendent and quality control personnel to assure that material is not left in areas where they can get into operating systems.
- H. Provide temporary, insulated, weathertight closure over openings above grade in buildings to remain.
1. **Closures shall remain in place at all times except as directed by Owners and as required for demolition and construction operations.**
  2. **Closure shall be constructed to prevent water and material from entering building opening. Construct closure to protect interior of building from weather.**
  3. **Closure shall be adequate in strength and anchorage to withstand uplift and wind loading in accordance with ANSI A58.1.**
  4. **Repair and maintain closure until Work is accepted as complete. Damage by other contractors will be repaired at their expense.**
  5. **Closure not replaced by permanent construction under this contract will be removed later by Owner under separate contract.**

### 3.04 DEMOLITION OF MECHANICAL ITEMS

- A. Remove mechanical equipment and materials as shown on Drawings and as specified.
- B. Removal shall include but not limited to piping, valves, air handling equipment, ductwork, controls, hangers, and associated accessories.

### 3.05 DEMOLITION OF ELECTRICAL ITEMS

- A. Examination:
1. **Verify that abandoned wiring and equipment serve only abandoned facilities.**
  2. **Demolition drawings are based on cursory field observation and existing record documents. Report discrepancies to Owner before disturbing existing installation.**
- B. Preparation:

1. **Contact Owner to determine equipment items are to be salvaged and delivered to storage area. Other equipment shall become property of Contractor and shall be removed from job site.**
  2. **Disconnect electrical systems scheduled for removal.**
  3. **Provide temporary wiring and connections to maintain existing systems in service during construction.**
- C. Demolition and extension of existing electrical work:
1. **Remove, relocate, and extend existing installations to remain to accommodate new construction.**
  2. **Remove abandoned wiring to source of supply.**
  3. **Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.**
  4. **Repair adjacent construction and finishes damaged during demolition and extension work.**
  5. **Maintain safe access to existing electrical installations which remain active.**
- D. Disposal of equipment containing polychlorinated biphenyl compounds (PCBs): Transformers, capacitors, and lamp ballasts containing PCBs shall be disposed of in accordance with CFR 40 Part 761. Ballasts, even those labeled "no PCBs", shall be disposed of accordingly. Deliver equipment to an Environmental Protection Agency (EPA) approved incinerator or ballast recycling service for disposal. Provide Owner with manifest and certificate of destruction pursuant to CFR 40 Part 761, Subpart K.

### 3.06 SALVAGE OF MATERIALS

- A. Salvageable materials, except items specified to remain property of Owner, shall become property of Contractor and shall be removed from site as Work progresses.
- B. Certain equipment and material shall be removed and reinstalled as indicated on Drawings and specified herein. Contractor shall remove such items, store if required, and reinstall as indicated. In the event of loss or damage to such material or equipment, Contractor shall replace items without additional cost to Owner.

### 3.07 DISPOSAL OF MATERIALS

- A. Storage of materials to be removed not permitted to accumulate on site. Promptly remove and dispose of non-salvageable equipment and materials.
- B. Debris shall not be allowed to accumulate on roofs, floors, or in areas outside of and around any buildings being removed. Waste materials and debris resulting from Work shall be removed and disposed of daily by Contractor in disposal area obtained by Contractor.
- C. Burning of waste lumber and other building materials or trash on Site will not be permitted.
- D. No material, obstructions, or debris shall be placed or allowed to accumulate within 15' of any fire hydrant. Fire hydrants shall be accessible at all times.

### 3.08 PATCHING

- A. Patch openings in walls and roof caused by demolition. Use materials comparable to adjacent undisturbed surfaces for patching.
- B. Any new construction work that affects existing building structures shall be patched to match existing surrounding materials. This includes roofing, walls, walks, flooring ceilings, and any other materials that affect structural or architectural integrity of building.

### 3.09 REPAIR AND RESTORATION

- A. Contractor shall be responsible for damage to personnel, public, roadways, streets, structures, utilities, facilities, and equipment caused by operations and shall repair any damage at its own expense or replace items damaged beyond repair.
- B. Do not operate vehicles or equipment on existing construction or roadways that could be damaged.
- C. Grade areas disturbed by construction to smooth, uniform surfaces sloped to drain.
- D. Replace construction removed to facilitate operations with construction of equal quality to that removed.

### 3.10 CLEAN-UP

- A. Maintain public streets, alleys, or other thoroughfares used in carrying out disposal free of litter or soil attributable to this operation. Equip and load trucks or other vehicles to prevent leakage, blowing off, or other escape of any portion of whatsoever is being hauled. Cost incurred by Owner in cleaning up such litter will be charged to Contractor and deducted from monies due or to become due it under this contract.
- B. Upon completion of demolition work in each area, thoroughly clean area of materials not to remain.
- C. Remove materials (except paint) adhered to construction to remain.
- D. Leave areas in broom clean and vacuumed condition.

END OF SECTION

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Structural materials.
- B. Structural design requirements.
- C. Structural fabrication and erection.
- D. Shop painting.
- E. Inspection and testing.

## 1.02 INFORMATIONAL SUBMITTALS

- A. Product Data:
  - 1. List of manufactured materials proposed, identifying manufacturer and type.
- B. Quality assurance data:
  - 1. Certificates of compliance with standards specified for items specified in this Division.
  - 2. Certified copies of mill tests.
  - 3. Welder's qualifications.
  - 4. Weld inspection and testing reports: Submit 3 copies of reports to Owner. At a minimum, reports shall contain information required by IBC and following:
    - a. Inspecting agency, inspector, inspector's AWS certification, materials inspected, date of inspection, whether or not materials conformed to Contract requirements, repair work and follow-up inspection results.
    - b. Fabricator's AISC shop certification.
    - c. Weld test reports.
  - 5. Bolted connection inspection and testing reports: Submit 3 copies of report to Owner. Report shall contain following information:
    - a. Inspecting agency, inspector, and inspector's qualifications.
    - b. Connections tested and inspected, and date of test and inspection.
    - c. Whether or not connection conformed to contract requirements, rework of connections, and follow-up testing and inspection results.

## 1.03 ACTION SUBMITTALS

- A. Shop Drawings for structural materials:
  - 1. Shop Drawings for structural material
  - 2. Revised Shop Drawings shall be labeled with revision number and revision date with all changes clearly identified by "clouding," and signed and dated by engineer retained by Contractor certifying drawing revision.
  - 3. Shop Drawings submitted without seal, signature, date, certification statement of engineer retained by Contractor and not identifying revisions will be returned to Contractor without review.

## 1.04 QUALITY ASSURANCE

- A. Fabricator shall be certified by AISC Quality Certification Program.
- B. Owner will retain services of qualified, independent special inspectors to inspect and test fastener assemblies, installation and tightening of bolts and to perform inspection and testing of welds.

- C. Where tests or inspections indicate noncompliance with Contract Documents, repair or replace defective materials at Contractor's expense. Costs for retesting shall be borne by Contractor.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Structural steel:
1. W shapes: ASTM A992/A992M, Grade 50.
  2. C, MC and S shapes: ASTM A36/A36M .
  3. L shapes: ASTM A36/A36M.
  4. Plates: ASTM A36/A36M.
- B. Structural square and rectangular tubing: ASTM A500, Grade B.
- C. Structural pipes: ASTM A53/A53M, Grade B.
- D. Round HSS: ASTM A500, Grade B.
- E. Steel fasteners, plain finish:
1. High-strength bolts: ASTM A325/A325M,.
  2. Nuts: ASTM A194/A194M 2d or ASTM A563/A563M DH.
  3. Washers: ASTM F436/F436M; hardness of 38 to 45 H.C.
  4. Direct tension indicators: ASTM F959/F959M,.
  5. Twist off tension control bolts conforming to ASTM F1852 may be substituted for A325 bolts. Heads shall be heavy hex or round type.
- F. Standard bolts: ASTM A307.

### **2.02 STEEL FABRICATION**

- A. Conform to AISC "Specification for Structural Steel Buildings" and "Specification for Structural Joints using ASTM A325 or A490 Bolts," and "Code of Standard Practice for Steel Buildings and Bridges," except Section 4.2 of Code of Standard Practice does not apply.
- B. Welding: AWS D1.1.
- C. Shop connections: Either weld or use high-strength bolts, unless type is specifically shown.
- D. Field connections: Provide bolts for field connections except where shown otherwise on Drawings.
1. Use high-strength bolts. Use galvanized high-strength bolts when bolting galvanized steel.
  2. Use of high-strength bolts: Conform to "Specification for Structural Joints Using ASTM A325 or A490 Bolts," as approved by Research Council on Structural Connections of the Engineering Foundation, and published by AISC.
  3. Use standard bolts for members at temporary or removable locations, unless noted otherwise. Standard bolts may be used for channel-girt connections.
  4. Provide punchings to receive items furnished and erected by others if so instructed prior to fabrication. Details will be furnished after award of contract.
  5. If structural steel details (field welds vs. shop welds, etc.) shown on Drawings are not compatible with Contractor's erection procedures, detailer shall submit proposed modifications for Engineer's review.
- E. Close ends of pipe and tubular members with minimum 10-gage (4 mm) plate, seal welded to member.

### **2.03 FACTORY FINISHING**

- A. Surface preparation: Remove oil, grease, dirt, rust, loose mill scale, and other foreign elements by "Commercial Blast Cleaning" in accordance with SSPC-SP6. Surface profile shall comply with paint manufacturer's requirements.
- B. Omit paint from contact surfaces of slip-critical connections unless paint has been qualified by test in accordance with "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" as adopted by the AISC Research Council on Structural Connections. Manufacturer's certification shall include certified copy of test report.
- C. Omit shop prime coat:
  - 1. Sufficient distance from surfaces subject to field welding to prevent prime coat damage from welding process
- D. Leave unpainted steel clean and free from rust.
- E. Shop primer: As specified in Section 09 90 00.
- F. Shop primer: Apply one shop coat of "10-99 Rust Inhibitive Primer," by Tnemec Co., or equal; apply in accordance with manufacturer's directions including recommended coverage.
- G. Shop primer: Apply one shop coat of "90-97 Tnemec-Zinc," by Tnemec Co., Inc. or equal; apply in accordance with manufacturer's directions including recommended coverage.
- H. Finishing system:
  - 1. Anticorrosive paint: Comply with GS-03.

### **PART 3 EXECUTION**

#### **3.01 ERECTION**

- A. Erect plumb and level; introduce temporary bracing required to support erection loads.
- B. Provide washers, install, and tighten high-strength bolts in accordance with "Specification for Structural Joints Using ASTM A325 or A490 Bolts," as approved by Research Council on Structural Connections of the Engineering Foundation, and published by AISC. Tighten bolts used in slip-critical connections or bolts subject to tension by "Direct Tension Indicator Tightening" method.
- C. Welding: AWS D1.1. Provide Engineer with proof of qualification of welders. Proof of qualification not required for tack welds or welds not carrying stress.
- D. Shore existing members when unbolting of common connections is required. Use new bolts for rebolting connections.
- E. Where new steel connects to existing steel and connections are not common connections, field drill holes in existing steel; welding to existing steel will be permitted only in special cases.
- F. Design, install, and maintain temporary guardrails and kickplates as required by OSHA.
- G. Exercise care in handling finished painted items to prevent abrasions during handling.

#### **3.02 INSPECTION AND TESTING OF BOLTED CONNECTIONS**

- A. Inspection and testing: In accordance with Section 9 of "Specification for Structural Joints Using ASTM A325 or A490 Bolts," Direct Tension Indicator (DTI) manufacturer's installation and inspection instructions, and these specifications.
- B. Inspection and testing shall also include following:

1. Verify that bolt, nut, washer, and DTI types conform to materials specified.
2. Verify bolts, nuts, washers and DTI are properly marked in accordance with appropriate ASTM specifications including manufacturer symbol.
3. Verify appropriate test certificates have been furnished by manufacturer for bolts, nuts, washers and DTI washers according to ASTM specification requirements.
4. Verify certificate lot numbers coincide with lot numbers on containers at job site.
5. Perform DTI calibration test and bolt assembly load test using Skidmore Wilhelm bolt tension calibrator. Minimum of 3 assemblies for each diameter and grade of bolt, nut, hardened washer and DTI shall be tested for each shipment.
6. Verify bolting crews are installing bolts in accordance with references specified.
7. Verify bearing-type connection bolts are snug tight bringing all plies into contact.

### 3.03 INSPECTION AND TESTING OF WELDS

- A. Inspection: IBC Chapter 17. Special inspector shall be retained by Owner. Special inspector shall be certified in accordance with AWS D1.1.

### 3.04 FIELD PAINTING

- A. After erection, apply one field coat of primer to cleaned surfaces of bolts, new welds, abrasions to shop coat, and all metal surfaces not shop prime painted except do not paint aluminum, stainless steel, or galvanized steel work.

END OF SECTION

- 1)
- 2)

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Steel roof deck.
- B. Deck accessories.
- C. Shop finish.
- D. Miscellaneous steel.

## 1.02 INFORMATIONAL SUBMITTALS

- A. Product Data:
  - 1. Manufacturer's product data for each mechanical fastener for each application (deck to deck and deck to support steel for each deck gage used on project).
- B. Quality assurance data:
  - 1. Deck ASTM designation.
  - 2. Welder's certification.

## 1.03 ACTION SUBMITTALS

- A. Shop Drawings: Erection plan and details for metal decking showing:
  - 1. Manufacturer; manufacturer's deck designation and certification statement that:
    - a. Roof deck complies with specified SDI deck designation and specification.
  - 2. Each decking level with dimensions defining limits of deck relative to column rows and splice locations.
  - 3. Method of attaching deck to support steel and deck-to-deck at side seams: location, spacing and type of deck fastener.
  - 4. Details at beams with studs where beam is parallel to deck span, showing deck flute details (split or use of girder closures) and stud placement. Coordinate with requirements shown on Drawings.
  - 5. Edge details, opening details and reinforcement.

## 1.04 QUALITY ASSURANCE

- A. Design and install metal deck in accordance with the latest edition of:
  - 1. SDI - "Specifications and Commentary for Composite Steel Floor Deck".
  - 2. SDI - "Specifications and Commentary for Non-Composite Steel Form Deck".
  - 3. SDI - "Specifications and Commentary for Steel Roof Deck".
- B. Welder qualifications: Competent workers qualified by tests prescribed by AWS to perform type of work required.

## 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store materials off ground with one end elevated on wood sleepers to provide drainage. Protect deck from elements with waterproof covering and ventilate to avoid condensation.

**PART 2 PRODUCTS**

## 2.01 MANUFACTURERS

- A. United Steel Deck, Inc.

B. Vulcraft, Division of Nucor Corporation.

C. Wheeling Corrugating Company.

## 2.02 DESIGN REQUIREMENTS

A. Minimum uncoated thicknesses for gages of metal deck specified:

1. 18-gage, 0.045" (1.14 mm).
2. 16-gage, 0.057" (1.45 mm).

## 2.03 MATERIALS

## 2.04 METAL DECK

A. Roof deck:

1. Material: ASTM A653/A653M (galvanized decks) having minimum yield strength of 33 ksi (230 MPa).

## 2.05 FACTORY FINISHING

A. Galvanized: Thoroughly clean steel and galvanize in accordance with ASTM A653/A653M G60.

## 2.06 FABRICATION

A. Fabricate deck in lengths to have 3 continuous spans or more wherever possible but no less than 2 spans.

B. Provide minimum 2" (50 mm) lap at deck joints over support steel.

## PART 3 EXECUTION

### 3.01 METAL DECK INSTALLATION

A. Provide miscellaneous steel to provide support to deck at terminations of deck and openings.

B. Shop cut each deck opening larger than 16 sq ft (1.5 m<sup>2</sup>) for which size and location can be determined at time of fabrication.

C. Field cut skew cuts, deck openings smaller than 16 sq ft (1.5 m<sup>2</sup>), and other openings for which size and location cannot be determined at time of fabrication.

D. Welding:

1. Attach deck to structural supports in accordance with manufacturer's recommendations for specific deck sections and Contract Documents; electric arc welding performed from topside of deck.
2. Welding: AWS D1.1 and D1.3.
3. Weld metal shall penetrate all layers of deck material at end laps and side joints and have good fusion to supporting members.
4. Arc spot welds (puddle welds) to support steel shall have minimum diameter of 5/8" (16 mm) or elongated weld of 3/8" (10 mm) minimum by 1-1/4" (32 mm) minimum length.
5. Use welding washers for deck thinner than 22-gage. Not permitted for decks 22-gage or thicker.

### 3.02 FIELD PAINTING

A. After deck has been installed, thoroughly clean and touch up abrasions of shop finish on top and bottom sides of decking, including cuts, drilled holes, rust spots, welds and weld scars, with air drying coating similar to shop-applied finish.

END OF SECTION

- 1)
- 2)

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. Firestopping for penetrations through fire-resistance rated walls and partitions, including both empty openings and openings containing cables, cable trays, pipes, ducts, conduits and other penetrating items.

### 1.02 SYSTEM DESCRIPTION

- A. Use appropriate firestop material and installation as necessary to meet required fire rating of penetrated, fire-rated wall or floor.
- B. Provide firestopping components compatible with each other, substrates forming openings, and items, if any, penetrating firestopping under conditions of service and application, as demonstrated by firestopping manufacturer based on testing and field experience.
- C. Provide components for each firestopping system needed to install fill materials and to comply with performance requirements specified herein. Use only components specified by firestopping manufacturer and approved by qualified testing and inspecting agency for designated fire-resistance rated system. Accessories include, but are not limited to, following:
  - 1. Sealants used in combination with other forming materials to prevent leakage of fill materials in liquid state.
  - 2. Collars.
  - 3. Steel sleeves.
- D. For products requiring mixing prior to application, comply with firestopping manufacturer's instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time and other procedures needed to produce firestopping products of uniform quality with optimum performance characteristics for application indicated.

### 1.03 PERFORMANCE REQUIREMENTS

- A. Provide firestopping systems produced and installed to resist spread of fire, according to requirements indicated, and passage of smoke and other gases.
- B. Provide through-penetration firestop systems with ratings as determined by ASTM E814, where indicated and where systems protect penetrating items exposed to contact with adjacent materials in floor areas to be occupied.
- C. Provide firestopping products that do not deteriorate when exposed to view, traffic, moisture, and physical damage.
  - 1. For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.
  - 2. For firestopping exposed to view, provide products with flame-spread values of less than 25 and smoke-developed values of less than 450, as determined by ASTM E84.

### 1.04 SUBMITTALS

- A. Product Data:
  - 1. Manufacturer's Material Safety Data Sheet (MSDS) for each type of material to be installed.
  - 2. Certification by firestopping material manufacturer that products supplied comply with local regulations controlling use of Volatile Organic Compounds (VOCs) and are nontoxic to building occupants.

- B. Samples for selection and verification of color: Engineer reserves right to require sealant color samples for exposed areas.
- C. Test reports: Product test reports from, and based on test performed by, qualified testing and inspecting agency evidencing compliance of firestopping, with requirements based on comprehensive testing of current products.
- D. Quality assurance data:
  - 1. Indicate type of materials, installation methods, and relationship to adjoining construction for each through-penetration firestop system, and each kind of construction condition penetrated and kind of penetrating item.
  - 2. Include firestop design designation of qualified testing and inspecting agency evidencing compliance with requirements for each condition.
  - 3. Submit documentation, including illustrations, from qualified testing and inspecting agency applicable to each through-penetration firestop configuration for construction and penetrating items.
  - 4. Qualification data for firms and persons as specified below to demonstrate capabilities and experience.

#### 1.05 QUALITY ASSURANCE

- A. Qualifications: Installer shall be certified, licensed, or otherwise qualified by firestopping material manufacturer as having necessary experience, staff and training to install manufacturer's products in accordance with specified requirements.
- B. Regulatory requirements:
  - 1. Refer to attached ICC(International Code Council) document. Firestopping material must comply with and submit ICC listing and/or compliance report.
  - 2. Provide firestopping complying with following fire-test-response characteristics requirements:
    - a. Firestopping tests shall be performed by qualified testing and inspecting agency such as Underwriter's Laboratory (UL) or another agency acceptable to Authority Having Jurisdiction (AHJ).
    - b. Through-penetration firestop systems shall be identical to those tested in accordance with ASTM E814, under conditions where positive furnace pressure differential of at least 0.01" of water column is maintained at distance of 0.78" below fill materials surrounding penetrating item in test assembly.
    - c. Through-penetration firestop system products shall bear classification markings of qualified testing and inspecting agency.
    - d. Through-penetration firestop systems shall correspond to those indicated by reference to through-penetration firestop system designations listed by UL Fire Resistance Directory.
    - e. Fire-resistance rating of joint sealants shall correspond to those indicated by reference to design designations listed by UL Fire Resistance Directory.
    - f. Joint sealants, including backing materials, shall bear classification markings of qualified testing and inspecting agency.
  - 3. Provide firestopping products containing no detectable asbestos as determined by methods specified in 40 CFR Part 763, Subpart F, Appendix A, Section 1, "Polarized Light Microscopy".
- C. Coordinate construction of openings and penetrating items to ensure designated through-penetration firestop systems are installed in accordance with specified requirements.
- D. Owner and Engineer, or a designated representative, reserve right to review installed firestopping systems for compliance with specified requirements.

#### 1.06 ENVIRONMENTAL REQUIREMENTS

- A. Do not apply materials when temperature of substrate material and ambient air is below 60°F.

- B. Maintain minimum temperature before, during, and for 3 days after installation of materials.
- C. Provide ventilation in areas to receive solvent cured materials. Ventilation rate shall be in accordance with manufacturer's instructions by either natural means, or where inadequate, by forced air circulation.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials undamaged in manufacturer's clearly labeled, unopened containers, identified with brand, type, and UL label where applicable.
- B. Coordinate delivery of materials with scheduled installation date to allow minimum storage time at project site.
- C. Store materials under cover and protect from weather and damage in compliance with manufacturer's requirements.
- D. Comply with recommended procedure, precautions or remedies described in material safety data sheets as applicable.
- E. Do not use damaged or expired materials.

### **PART 2 PRODUCTS**

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Products listed are examples to be used only if appropriate to required installation. Other products may be necessary depending on conditions encountered.

#### 2.02 SILICONE ELASTOMERIC SEALANT

- A. Acceptable manufacturers:
  - 1. 3M Brand Fire Barrier Premium Latex CP 25 WB+ Caulk.
  - 2. Or approved equal in compliance with ICC listing standards.

#### 2.03 ACCESSORIES

- A. Dam material: Provide dam material, temporary or permanent, as recommended by firestopping manufacturer.
- B. Provide forming materials, backer rods, and fire-resistant fillers as necessary.
- C. Installation accessories: Clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.

### **PART 3 EXECUTION**

#### 3.01 EXAMINATION

- A. Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper or timely completion. Do not proceed with installation until unsatisfactory conditions have been corrected.

#### 3.02 PREPARATION

- A. Clean openings and joints immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer and following requirements:

1. Remove foreign materials from surfaces of openings and joint substrates and from penetrating items that could interfere from adhesion of firestopping.
  2. Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rest, laitance, release agents, water repellents, and any other substances that may affect proper adhesion.
- B. Provide masking tape and temporary covering to prevent damage or discoloration of adjacent surfaces by firestopping materials. Remove tape as soon as possible without disturbing firestopping's seal with substrates.
- C. Install backing or damming materials to arrest liquid material leakage.

### 3.03 INSTALLATION

- A. Install firestop materials in accordance with manufacturer's instructions and published "Through-Penetration Firestop Systems" in UL Fire Resistance Directory.
- B. Install material at walls or partition openings containing penetrating sleeves, piping, ductwork, conduit and other items, requiring firestopping.
- C. Install forming or damming materials and other accessories of types required to support fill materials during application and in position needed to produce 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.
- D. Apply firestopping material in sufficient thickness to achieve rating equal to rating of wall or floor construction through which opening penetrates, to a uniform density and texture.
- E. Completely fill voids and cavities formed by openings, forming materials, accessories and penetrating items. Apply materials to contact and adhere to substrates formed by openings and penetrating items.
- F. Tool non-sag sealants immediately after sealant application and prior to time skinning or curing begins. Form smooth, uniform beads of configuration indicated or required to produce fire-resistance rating, as well as to eliminate air pockets, and to ensure contact and adhesion of sealants with sides of joint. Remove excess sealant from surfaces adjacent to joint.
- G. Place sealant to completely seal junctions with adjacent dissimilar materials.
- H. Remove dam material after firestopping material has cured.
- I. Do not proceed to enclose firestopping with other construction until Owner, inspection agency, or representative has reviewed firestopping.
- J. Where deficiencies are found, repair or replace firestopping to comply with requirements.

### 3.04 CLEANING

- A. Clean surfaces adjacent to sealed openings and joints to be free of excess firestop materials and soiling as Work progresses.

### 3.05 PROTECTION

- A. Protect firestopping during and after curing period from contact with contaminating substances or damage from construction operations or other causes until completion of construction. If damage or deterioration occurs, remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.

END OF SECTION



## SECTION 075113 - BUILT-UP ASPHALT ROOFING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes built-up asphalt roofing.

#### 1.2 DEFINITION

- A. Hot Roofing Asphalt: Roofing asphalt heated to its equiviscous temperature, the temperature at which its viscosity is 125 centipoise for mop-applied roofing asphalt and 75 centipoise for mechanical spreader-applied roofing asphalt, within a range of plus or minus 25 deg F (14 deg C), measured at the mop cart or mechanical spreader immediately before application.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Roofing System Design: Provide built-up roofing system that is identical to the existing system.

#### 1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Maintenance data.
- C. Sample warranties.

#### 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by built-up roofing manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.
- B. Source Limitations: Obtain components for built-up roofing from same manufacturer as built-up roofing or approved by built-up roofing manufacturer.
- C. Preinstallation Roofing Conference: Conduct conference at Project site.

#### 1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of built-up roofing that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: 10 years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 BUILT-UP ROOFING MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Barrett Company.
  - 2. CertainTeed Corp.

3. Ecology Commercial and Industrial Roofing Systems.
4. Fields Company, LLC.
5. Firestone Building Products.
6. GAF Materials Corporation.
7. Hickman, W. P. Systems, Inc.
8. Johns Manville.
9. Malarkey Roofing Company.
10. TAMKO Building Products, Inc.
11. Tremco, Incorporated.
12. U.S. Intec, Inc.; Division of BMCA.

## 2.2 BASE-SHEET MATERIALS

- A. Sheathing Paper: Match existing.
- B. Base Sheet: Match existing.

## 2.3 ROOFING MEMBRANE PLIES

- A. Ply Sheet: Match existing.
- B. Cap Sheet: Match existing.

## 2.4 BASE FLASHING SHEET MATERIALS

- A. Backer Sheet: Match existing.
- B. Granule-Surfaced Flashing Sheet: Match existing

## 2.5 ASPHALT MATERIALS

- A. Asphalt Primer: ASTM D 41.
- B. Roofing Asphalt: Match existing.

## 2.6 AUXILIARY BUILT-UP ROOFING MATERIALS

- A. General: Auxiliary materials recommended by roofing manufacturer for intended use and compatible with built-up roofing.
  1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
  2. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
    - a. Plastic Foam Adhesives: 50 g/L.
    - b. Gypsum Board and Panel Adhesives: 50 g/L.
    - c. Multipurpose Construction Adhesives: 70 g/L.
    - d. Fiberglass Adhesives: 80 g/L.
    - e. Contact Adhesives: 80 g/L.

- f. Other Adhesives: 250 g/L.
  - g. Nonmembrane Roof Sealants: 300 g/L.
  - h. Sealant Primers for Nonporous Substrates: 250 g/L.
  - i. Sealant Primers for Porous Substrates: 775 g/L.
- B. Cold-Applied Adhesive: Roofing manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied adhesive specially formulated for compatibility and use with built-up base flashings.
  - C. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing manufacturer for application.
  - D. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening built-up roofing components to substrate, tested by manufacturer for required pullout strength, and acceptable to roofing manufacturer.
  - E. Aggregate Surfacing: Match existing.

## 2.7 SUBSTRATE BOARDS

- A. Substrate Board: Match existing.
- B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening substrate board to roof deck.

## 2.8 ROOF INSULATION

- A. Match existing rigid insulation.

## 2.9 INSULATION ACCESSORIES

- A. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation to substrate and acceptable to roofing manufacturer.
- B. Cold-Applied Insulation Adhesive: Insulation manufacturer's recommended asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.
- C. Insulation Cant Strips: Match existing.
- D. Cover Board: Match existing.

## 2.10 WALKWAYS

- A. Walkway Pads: Match existing

## PART 3 - EXECUTION

### 3.1 SUBSTRATE BOARD INSTALLATION

- A. Install substrate board with long joints in continuous straight lines, perpendicular to roof slopes with end joints staggered between rows. Tightly butt substrate boards together.
  - 1. Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to built-up roofing manufacturer's written instructions.

### 3.2 INSULATION INSTALLATION

- A. Comply with built-up roofing manufacturer's written instructions for installing roof insulation.
- B. Nailer Strips: Mechanically fasten 4-inch nominal- (89-mm actual-) width wood nailer strips of same thickness as insulation perpendicular to sloped roof deck at the following spacing:
- C. Insulation Cant Strips: Install and secure preformed 45-degree insulation cant strips at junctures of built-up roofing with vertical surfaces or angle changes greater than 45 degrees.
- D. Install tapered insulation under area of roofing to conform to slopes indicated.
- E. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches (68 mm) or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches (150 mm) in each direction.
  - 1. Where installing composite and noncomposite board insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.
- F. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.
- G. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:
  - 1. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. (0.3 L/sq. m) and allow primer to dry.
  - 2. Set each layer of insulation in a solid mopping of hot roofing asphalt.
  - 3. Set each layer of insulation in cold-applied insulation adhesive, firmly pressing and maintaining insulation in place.
- H. Mechanically Fastened Insulation: Install each layer of insulation and secure to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
  - 1. Fasten insulation to resist uplift pressure at corners, perimeter, and field of roof.
- I. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
  - 1. Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
  - 2. Set each subsequent layer of insulation in a solid mopping of hot roofing asphalt.
  - 3. Set each subsequent layer of insulation in cold-applied insulation adhesive, firmly pressing and maintaining insulation in place.
- J. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction. Loosely butt cover boards together and fasten to roof deck.
  - 1. Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.
  - 2. Apply hot roofing asphalt to underside and immediately bond cover board to substrate.

### 3.3 BUILT-UP ROOFING INSTALLATION

- A. Install roofing membrane according to roofing manufacturer's written instructions and applicable recommendations of ARMA/NRCA's "Quality Control Guidelines for the Application of Built-up Roofing."

- B. Coordinate installation of roofing so insulation and other components of built-up roofing not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.
- C. Substrate-Joint Penetrations: Prevent roofing asphalt and adhesives from penetrating substrate joints, entering building, or damaging built-up roofing components or adjacent building construction.
- D. Loosely lay one course of sheathing paper, lapping edges and ends a minimum of 2 inches (50 mm) and 6 inches (150 mm), respectively.
- E. Install lapped base sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:
  - 1. Mechanically fasten to substrate.
  - 2. Spot- or strip-mop to substrate with hot roofing asphalt.
  - 3. Adhere to substrate in a solid mopping of hot roofing asphalt.
- F. Install three ply sheets starting at low point of roofing. Align ply sheets without stretching. Shingle side laps of ply sheets uniformly to achieve required number of plies throughout thickness of roofing membrane. Shingle in direction to shed water. Extend ply sheets over and terminate beyond cants.
  - 1. Embed each ply sheet in a solid mopping of hot roofing asphalt applied at rate required by roofing manufacturer, to form a uniform membrane without ply sheets touching.
- G. Cap Sheet: Install lapped granulated cap sheet starting at low point of roofing. Offset laps from laps of preceding ply sheets and align cap sheet without stretching. Lap in direction to shed water. Extend cap sheet over and terminate beyond cants.
  - 1. Embed cap sheet in a solid mopping of hot roofing asphalt applied at rate required by built-up roofing manufacturer.
- H. Aggregate Surfacing: Promptly after installing roofing membrane, base flashing, and stripping, flood-coat roof surface with 60 lb/100 sq. ft. (3.0 kg/sq. m) of hot roofing asphalt. While flood coat is hot and fluid, cast the following average weight of aggregate in a uniform course:

### 3.4 FLASHING AND STRIPPING INSTALLATION

- A. Install base flashing over cant strips and other sloping and vertical surfaces, at roof edges, and at penetrations through roof, and secure to substrates according to built-up roofing manufacturer's written instructions.
- B. Extend base flashing up walls or parapets a minimum of 8 inches (200 mm) above built-up roofing and 4 inches (100 mm) onto field of built-up roofing.
- C. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.
- D. Install stripping, according to roofing manufacturer's written instructions, where metal flanges and edgings are set on built-up roofing.

### 3.5 WALKWAY INSTALLATION

- A. Walkway Pads: Install walkway pads using units of size indicated or, if not indicated, of manufacturer's standard size, according to walkway pad manufacturer's written instructions.

END OF SECTION 075113

## SECTION 076200 - SHEET METAL FLASHING AND TRIM

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Manufactured reglets.
  - 2. Formed low-slope roof sheet metal fabrications.
  - 3. Formed wall sheet metal fabrications.

#### 1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation layouts of sheet metal flashing and trim, including plans, elevations, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work.
  - 1. Include details for forming, joining, supporting, and securing sheet metal flashing and trim, including pattern of seams, termination points, fixed points, expansion joints, expansion-joint covers, edge conditions, special conditions, and connections to adjoining work.
- C. Samples: For each exposed product and for each finish specified.
- D. Maintenance data.
- E. Warranty: Sample of special warranty.

#### 1.3 QUALITY ASSURANCE

- A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.
- B. Preinstallation Conference: Conduct conference at Project site.

#### 1.4 WARRANTY

- A. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 SHEET METALS

- A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.

#### 2.2 UNDERLAYMENT MATERIALS

- A. Slip Sheet: Building paper, 3-lb/100 sq. ft. (0.16-kg/sq. m) minimum, rosin sized.

### 2.3 MISCELLANEOUS MATERIALS

- A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.
- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
  - 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
    - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating.
    - b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
    - c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
- C. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
- D. Elastomeric Sealant: ASTM C 920, elastomeric polymer sealant; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

### 2.4 REGLETS

- A. Reglets: Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions with interlocking counterflashing on exterior face, of same metal as reglet.
  - 1. Material: Galvanized steel, 0.022 inch (0.56 mm) thick.
  - 2. Finish: With manufacturer's standard color coating.

### 2.5 FABRICATION, GENERAL

- A. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness, and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.
  - 1. Obtain field measurements for accurate fit before shop fabrication.
  - 2. Form sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
  - 3. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces exposed to view.
- B. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant.
- C. Expansion Provisions: Where lapped expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
- D. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

- E. Seams: Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
- F. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use.

### PART 3 - EXECUTION

#### 3.1 UNDERLAYMENT INSTALLATION

- A. Polyethylene Sheet: Install polyethylene sheet with adhesive for anchorage. Apply in shingle fashion to shed water, with lapped and taped joints of not less than 2 inches (50 mm).
- B. Felt Underlayment: Install felt underlayment with adhesive for temporary anchorage. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).
- C. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.

#### 3.2 INSTALLATION, GENERAL

- A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement so that completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
  - 1. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
  - 2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
  - 3. Space cleats not more than 12 inches (300 mm) apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.
  - 4. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
  - 5. Install sealant tape where indicated.
  - 6. Torch cutting of sheet metal flashing and trim is not permitted.
- B. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by SMACNA.
  - 1. Coat back side of sheet metal flashing and trim with bituminous coating where flashing and trim will contact wood, ferrous metal, or cementitious construction.
  - 2. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet or install a course of polyethylene sheet.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.

- D. Fastener Sizes: Use fasteners of sizes that will penetrate wood sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws.
- E. Seal joints as shown and as required for watertight construction.

### 3.3 ROOF FLASHING INSTALLATION

- A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
- B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in SMACNA's "Architectural Sheet Metal Manual" and as indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at staggered 3-inch (75-mm) centers.
- C. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.
- D. Cap Flashing: Cap Flashing joints to be standing seam.

### 3.4 WALL FLASHING INSTALLATION

- A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to SMACNA recommendations and as indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Reglets: Installation of reglets is specified in Division 04 Section "Unit Masonry."

### 3.5 CLEANING AND PROTECTION

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean and neutralize flux materials. Clean off excess solder and sealants.
- C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.

END OF SECTION 076200

## SECTION 077200 - ROOF ACCESSORIES

### 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. Roof curbs.
- B. Related Sections include the following:
  - 1. Division 06 Section "Rough Carpentry" for roof sheathing, wood cants, and wood nailers.
  - 2. Division 07 Section "Sheet Metal Flashing and Trim" for shop- and field-fabricated metal flashing and counterflashing, roof expansion-joint covers, and miscellaneous sheet metal trim and accessories.
  - 3. Division 23 Section "HVAC Power Ventilators" for power roof-mounted ventilators.

#### 1.3 SUBMITTALS

- A. Product Data: For each type of roof accessory indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Shop Drawings: Show fabrication and installation details for roof accessories. Show layouts of roof accessories including plans and elevations. Indicate dimensions, weights, loadings, required clearances, method of field assembly, and components. Include plans, elevations, sections, details, and attachments to other work.
- C. Samples: For each type of exposed factory-applied color finish required and for each type of roof accessory indicated, prepared on Samples of size to adequately show color.

#### 1.4 QUALITY ASSURANCE

- A. Sheet Metal Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" details for fabrication of units, including flanges and cap flashing to coordinate with type of roofing indicated.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

- A. Pack, handle, and ship roof accessories properly labeled in heavy-duty packaging to prevent damage.

#### 1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify required openings for each type of roof accessory by field measurements before fabrication and indicate measurements on Shop Drawings.

#### 1.7 COORDINATION

- A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.

## 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, manufacturers listed in other Part 2 articles.

### 2.2 METAL MATERIALS

- A. Roof Curbs: Provide metal roof curbs, internally reinforced and capable of supporting superimposed live and dead loads, including equipment loads and other construction to be supported on roof curbs. Fabricate with welded or sealed mechanical corner joints, with stepped integral metal cant raised the thickness of roof insulation and integral formed mounting flange at perimeter bottom. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.
  - 1. Material: Galvanized steel sheet, 0.079 inch (2.0 mm) thick.
    - a. Finish: High-performance organic coating.
  - 2. Curb height may be determined by adding thickness of roof insulation and minimum base flashing height recommended by roofing membrane manufacturer. Fabricate units to minimum height of 12 inches (300 mm), unless otherwise indicated.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of work.
  - 1. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored and is ready to receive roof accessories.
  - 2. Verify dimensions of roof openings for roof accessories.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. General: Install roof accessories according to manufacturer's written instructions. Anchor roof accessories securely in place and capable of resisting forces specified. Use fasteners, separators, sealants, and other miscellaneous items as required for completing roof accessory installation. Install roof accessories to resist exposure to weather without failing, rattling, leaking, and fastener disengagement.
- B. Install roof accessories to fit substrates and to result in watertight performance.
- C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
  - 1. Coat concealed side of roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
  - 2. Underlayment: Where installing exposed-to-view components of roof accessories directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet, or install a course of polyethylene underlayment.
  - 3. Bed flanges in thick coat of asphalt roofing cement where required by roof accessory manufacturers for waterproof performance.

- D. Install roof accessories level, plumb, true to line and elevation, and without warping, jogs in alignment, excessive oil canning, buckling, or tool marks.
- E. Roof Curb Installation:
  - 1. Set roof curb so top surface of roof curb is level.
- F. Seal joints with elastomeric sealant as required by manufacturer of roof accessories.

### 3.3 TOUCH UP

- A. Touch up factory-primed surfaces with compatible primer ready for field painting in accordance with Division 09 painting Sections.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

### 3.4 CLEANING

- A. Clean exposed surfaces according to manufacturer's written instructions.

END OF SECTION 077200

## SECTION 079200 - JOINT SEALANTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes joint sealants for the following applications, including those specified by reference to this Section:
  - 1. Exterior joints in vertical surfaces and horizontal nontraffic surfaces.
  - 2. Interior joints in vertical surfaces and horizontal nontraffic surfaces.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.
- B. Provide joint sealants for interior applications that establish and maintain airtight and water-resistant continuous joint seals without staining or deteriorating joint substrates.

#### 1.3 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Samples: For each type and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- C. Preconstruction field test reports.
- D. Compatibility and adhesion test reports.
- E. Product test reports.

#### 1.4 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 ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
- B. Preconstruction Field-Adhesion Testing: Before installing elastomeric sealants, field test their adhesion to Project joint substrates according to the method in ASTM C 1193 that is appropriate for the types of Project joints.

#### 1.5 WARRANTY

- A. Special Installer's Warranty: Installer's standard form in which Installer agrees to repair or replace elastomeric joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
  - 1. Warranty Period: Two years from date of Substantial Completion.

- B. Special Manufacturer's Warranty: Manufacturer's standard form in which elastomeric sealant manufacturer agrees to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
  - 1. Warranty Period: 10 years from date of Substantial Completion.

## 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, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer, based on testing and field experience.
- B. VOC Content of Interior Sealants: Provide interior sealants and sealant primers that comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
  - 1. Sealants: 250 g/L.
  - 2. Sealant Primers for Nonporous Substrates: 250 g/L.
  - 3. Sealant Primers for Porous Substrates: 775 g/L.
- C. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

### 2.3 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- B. Stain-Test-Response Characteristics: Where elastomeric sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- C. Multicomponent Nonsag Urethane Sealant:
  - 1. Available Products:
    - a. Schnee-Morehead, Inc.; Permthane SM 7200.
    - b. Sika Corporation, Inc.; Sikaflex - 2c NS TG.
    - c. Sonneborn, Division of ChemRex Inc.; NP 2.
    - d. Tremco; Vulkem 227.
    - e. Tremco; Vulkem 322 DS.
  - 2. Type and Grade: M (multicomponent) and NS (nonsag).
  - 3. Class: 25.

4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, [G, ]A, and, as applicable to joint substrates indicated, O.

#### 2.4 JOINT-SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, Type **C** (closed-cell material with a surface skin), O (open-cell material), B (bicellular material with a surface skin) or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:
- C. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F (minus 32 deg C). Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and to otherwise contribute to optimum sealant performance.
- D. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

#### 2.5 MISCELLANEOUS MATERIALS

- A. Primer: Material 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. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants.
  1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant.
    - a. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air.
  2. Remove laitance and form-release agents from concrete.

- a. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
- B. Joint Priming: Prime joint substrates, where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

### 3.2 INSTALLATION

- A. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- B. Acoustical Sealant Application Standard: Comply with recommendations in ASTM C 919 for use of joint sealants in acoustical applications as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
  - 1. Do not leave gaps between ends of sealant backings.
  - 2. Do not stretch, twist, puncture, or tear sealant backings.
  - 3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
  - 1. Place sealants so they directly contact and fully wet joint substrates.
  - 2. Completely fill recesses in each joint configuration.
  - 3. 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 according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
  - 1. Remove excess sealant from surfaces adjacent to joints.
  - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
  - 3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.

- G. Installation of Preformed Silicone-Sealant System: Comply with manufacturer's written instructions.
- H. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping, taking care not to pull or stretch material, producing seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures where expansion of sealant requires acceleration to produce seal, apply heat to sealant in compliance with sealant manufacturer's written instructions.
- I. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

END OF SECTION 079200

## SECTION 092216 - NON-STRUCTURAL METAL FRAMING

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Non-load-bearing steel framing systems for interior gypsum board assemblies.
2. Suspension systems for interior gypsum ceilings and soffits.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: Provide materials and construction identical to those tested according to ASTM E 119.
- B. STC-Rated Assemblies: Provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413.

#### 2.2 FRAMING SYSTEMS

- A. Steel Studs and Runners: ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners of equivalent minimum base-metal thickness.
1. Minimum Base-Metal Thickness: As indicated on Drawings.
  2. Depth: As indicated on Drawings.
- B. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
- C. Cold-Rolled Channel Bridging: Steel, 0.053-inch (1.34-mm) minimum base-metal thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
- D. Hat-Shaped, Rigid Furring Channels: ASTM C 645.
- E. Resilient Furring Channels: 1/2-inch- (13-mm-) deep, steel sheet members designed to reduce sound transmission.
- F. Cold-Rolled Furring Channels: 0.053-inch (1.34-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
- G. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (31.8 mm), wall attachment flange of 7/8 inch (22 mm), minimum uncoated-metal thickness of 0.018 inch (0.45 mm), and depth required to fit insulation thickness indicated.

#### 2.3 SUSPENSION SYSTEMS

- A. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

- B. Hanger Attachments to Concrete:
  - 1. Anchors: Capable of sustaining a load equal to 5 times that imposed as determined by ASTM E 488.
    - a. Type: Postinstalled, chemical anchor or Postinstalled, expansion anchor.
  - 2. Powder-Actuated Fasteners: Capable of sustaining, a load equal to 10 times that imposed as determined by ASTM E 1190.
- C. Wire Hangers: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.
- D. Flat Hangers: Steel sheet, in size indicated on Drawings.
- E. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.053 inch (1.34 mm) and minimum 1/2-inch- (13-mm-) wide flanges.
  - 1. Depth: As indicated on Drawings.
- F. Furring Channels (Furring Members):
  - 1. Cold-Rolled Channels: 0.053-inch (1.34-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges, 3/4 inch (19 mm) deep.
  - 2. Steel Studs and Runners: ASTM C 645. Use either steel studs and runners or dimpled steel studs and runners of equivalent minimum base-metal thickness.
  - 3. Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch (22 mm) deep.
  - 4. Resilient Furring Channels: 1/2-inch- (13-mm-) deep members designed to reduce sound transmission.

## 2.4 AUXILIARY MATERIALS

- A. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.
- B. Isolation Strip at Exterior Walls: Provide asphalt saturated organic felt or foam gasket.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, GENERAL

- A. Installation Standard: ASTM C 754.
  - 1. Gypsum Plaster Assemblies: Also comply with requirements in ASTM C 841 that apply to framing installation.
  - 2. Portland Cement Plaster Assemblies: Also comply with requirements in ASTM C 1063 that apply to framing installation.
  - 3. Gypsum Veneer Plaster Assemblies: Also comply with requirements in ASTM C 844 that apply to framing installation.
  - 4. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.
- B. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- C. Install bracing at terminations in assemblies.

- D. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

### 3.2 INSTALLING FRAMED ASSEMBLIES

- A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
- B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.
- C. Install studs so flanges within framing system point in same direction.
- D. Install tracks (runners) at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts penetrating partitions above ceiling.
  - 1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
  - 2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.
    - a. Install two studs at each jamb unless otherwise indicated.
    - b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch (13-mm) clearance from jamb stud to allow for installation of control joint in finished assembly.
    - c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
  - 3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
  - 4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
    - a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
  - 5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
  - 6. Curved Partitions:
    - a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.
    - b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of no fewer than two studs at ends of arcs, place studs 6 inches (150 mm) o.c.
- E. Direct Furring:
  - 1. Screw to wood framing.
  - 2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.

F. Z-Furring Members:

1. Erect insulation vertically and hold in place with Z-furring members spaced 24 inches o.c.
2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches (305 mm) from corner and cut insulation to fit.

- G. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.3 INSTALLING SUSPENSION SYSTEMS

- A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

- B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

- C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.
  - a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.
3. Do not attach hangers to steel roof deck.
4. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
5. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
6. Do not connect or suspend steel framing from ducts, pipes, or conduit.

- D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

- E. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

- F. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet (3 mm in 3.6 m) measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION 092216

## SECTION 092900 - GYPSUM BOARD

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Interior gypsum board.
  - 2. Exterior gypsum board for ceilings and soffits.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.
- C. Low Emitting Materials: For ceiling and wall assemblies, provide materials and construction identical to those tested in assembly and complying with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

#### 2.2 INTERIOR GYPSUM BOARD

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. American Gypsum.
  - 2. CertainTeed Corp.
  - 3. Georgia-Pacific Gypsum LLC.
  - 4. Lafarge North America Inc.
  - 5. National Gypsum Company.
  - 6. PABCO Gypsum.
  - 7. Temple-Inland.
  - 8. USG Corporation.
- B. Gypsum Board, Type X: ASTM C 1396/C 1396M.
  - 1. Thickness: 5/8 inch (15.9 mm).
  - 2. Long Edges: Tapered.

C. Gypsum Ceiling Board: ASTM C 1396/C 1396M.

1. Thickness: 1/2 inch (12.7 mm).
2. Long Edges: Tapered.

2.3 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized steel sheet.

B. Aluminum Trim: ASTM B 221 (ASTM B 221M), Alloy 6063-T5.

2.4 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:

1. Interior Gypsum Board: Paper.
2. Exterior Gypsum Soffit Board: Paper.
3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
4. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Board: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

2.5 AUXILIARY MATERIALS

A. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

1. Laminating adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Laminating adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Steel Drill Screws: ASTM C 1002, unless otherwise indicated.

C. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing).

D. Acoustical Joint Sealant: ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings as demonstrated by testing according to ASTM E 90.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
  - a. Accumetric LLC; BOSS 824 Acoustical Sound Sealant.
  - b. Grabber Construction Products; Acoustical Sealant GSC.

- c. Specified Technologies, Inc.; Smoke N Sound Acoustical Sealant.
  - d. USG Corporation; SHEETROCK Acoustical Sealant.
2. Acoustical joint sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Acoustical joint sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Thermal Insulation: As specified in Division 07 Section "Thermal Insulation."
  - F. Vapor Retarder: As specified in Division 07 Section "Thermal Insulation."

### PART 3 - EXECUTION

#### 3.1 APPLYING AND FINISHING PANELS

- A. Comply with ASTM C 840.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments, except floors. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- D. Install trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- E. Prefill open joints and damaged surface areas.
- F. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.
- G. Protect adjacent surfaces from drywall compound and texture finishes and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- H. Remove and replace panels that are wet, moisture damaged, and mold damaged.

END OF SECTION 092900

## SECTION 095113 - ACOUSTICAL PANEL CEILINGS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes acoustical panels and exposed suspension systems for ceilings.

#### 1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Coordination Drawings: Drawn to scale and coordinating acoustical panel ceiling installation with hanger attachment to building structure and ceiling mounted items:
- C. Samples: For each exposed finish.
- D. Product test reports.
- E. Research/evaluation reports.
- F. Maintenance data.

#### 1.3 QUALITY ASSURANCE

- A. Acoustical Testing Agency Qualifications: An independent testing laboratory or an NVLAP-accredited laboratory.
- B. Fire-Test-Response Characteristics:
  - 1. Fire-Resistance Characteristics: Where indicated, provide acoustical panel ceilings identical to those of assemblies tested for fire resistance per ASTM E 119 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
    - a. Identify materials with appropriate markings of applicable testing and inspecting agency.
  - 2. Surface-Burning Characteristics: Acoustical panels complying with ASTM E 1264 for Class B materials, when tested per ASTM E 84.
    - a. Smoke-Developed Index: 450 or less.
- C. Seismic Standard: Comply with the following:
  - 1. Standard for Ceiling Suspension Systems Requiring Seismic Restraint: Comply with ASTM E 580.
- D. Preinstallation Conference: Conduct conference at Project site.

#### 1.4 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. Acoustical Ceiling Panels: Full-size panels equal to 2.0 percent of quantity installed.
  - 2. Suspension System Components: Quantity of each exposed component equal to 2.0 percent of quantity installed.

## PART 2 - PRODUCTS

### 2.1 ACOUSTICAL PANEL CEILINGS, GENERAL

- A. Acoustical Panel Standard: Comply with ASTM E 1264.
- B. Metal Suspension System Standard: Comply with ASTM C 635.
- C. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
  - 1. Anchors in Concrete: Expansion or Bonded anchors fabricated from corrosion-resistant materials, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing per ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
  - 2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
- D. Wire Hangers, Braces, and Ties: Zinc-coated carbon-steel wire; ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
  - 1. Size: Select wire diameter so its stress at 3 times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- (2.69-mm-) diameter wire.
- E. Seismic perimeter stabilizer bars, seismic struts, and seismic clips.
- F. Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension system runners.

### 2.2 ACOUSTICAL PANELS FOR ACOUSTICAL PANEL CEILING

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- B. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Armstrong World Industries, Inc.
  - 2. BPB USA.
  - 3. Chicago Metallic Corporation.
  - 4. Ecophon CertainTeed, Inc.
  - 5. Tectum Inc.
  - 6. USG Interiors, Inc.
- C. Classification: Provide panels complying with ASTM E 1264 for type and form as follows:
  - 1. Type and Form: Match existing
- D. Color: Match existing.

- E. Edge/Joint Detail: Match existing.
- F. Thickness: Match existing.
- G. Modular Size: 24 by 48 inches.

### 2.3 METAL SUSPENSION SYSTEM FOR ACOUSTICAL PANEL CEILING

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
- B. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Armstrong World Industries, Inc.
  - 2. BPB USA.
  - 3. Chicago Metallic Corporation.
  - 4. Ecophon CertainTeed, Inc.
  - 5. USG Interiors, Inc.
- C. Double-Web Steel Suspension System: Match existing.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with ASTM C 636 and seismic design requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
- B. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders.
- C. Suspend ceiling hangers from building's structural members, plumb and free from contact with insulation or other objects within ceiling plenum. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers, use trapezes or equivalent devices. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
  - 1. Do not support ceilings directly from permanent metal forms or floor deck; anchor into concrete slabs.
  - 2. Do not attach hangers to steel deck tabs or to steel roof deck.
- D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3.2 mm in 3.6 m). Miter corners accurately and connect securely.
- E. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- F. Install acoustical panels with undamaged edges and fit accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

END OF SECTION 095113

## SECTION 096513 - RESILIENT BASE AND ACCESSORIES

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Resilient base.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

- B. Samples: For each type of product indicated, in manufacturer's standard-size Samples but not less than 12 inches (300 mm) long, of each resilient product color, texture, and pattern required.

#### 1.3 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: As determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.

1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

#### 1.4 PROJECT CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer in spaces to receive resilient products.

- B. Until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer.

C. Install resilient products after other finishing operations, including painting, have been completed.

#### 1.5

### PART 2 - PRODUCTS

#### 2.1 RESILIENT BASE

A. Resilient Base:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following (Match existing or provide per UVU standard spec):

- a. Armstrong World Industries, Inc.
  - b. Flexco, Inc.
  - c. Johnsonite.
  - d. Mondo Rubber International, Inc.
  - e. Roppe Corporation, USA.
- B. Resilient Base Standard: ASTM F 1861.
1. Material Requirement: Type TS (rubber, vulcanized thermoset) or Type TP (rubber, thermoplastic). Match existing or provide per UVU standard spec.
  2. Manufacturing Method: Group I (solid, homogeneous). Match existing or provide per UVU standard spec.
  - 3.
  4. Style: Cove (base with toe). Match existing or provide per UVU standard spec.
- C. Minimum Thickness: 0.125 inch (3.2 mm).
1. Height: 4 inches (102 mm). Match existing or provide per UVU standard spec.
- D. Lengths: Coils in manufacturer's standard length.
- E. Outside Corners: Preformed.
- F. Inside Corners: Job formed.
- G. Finish: Matte or Match existing or provide per UVU standard spec.
- H. Colors and Patterns: Match existing or provide per UVU standard spec.

## 2.2 INSTALLATION MATERIALS

- A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by manufacturer for applications indicated.
- B. Adhesives: Water-resistant type recommended by manufacturer to suit resilient products and substrate conditions indicated.
1. Adhesives shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.
- B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound and remove bumps and ridges to produce a uniform and smooth substrate.

- C. Do not install resilient products until they are same temperature as the space where they are to be installed.
  - 1. Move resilient products and installation materials into spaces where they will be installed at least 48 hours in advance of installation.
- D. Sweep and vacuum clean substrates to be covered by resilient products immediately before installation.

### 3.2 RESILIENT BASE INSTALLATION

- A. Comply with manufacturer's written instructions for installing resilient base.
- B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.
- C. Install resilient base in lengths as long as practicable without gaps at seams and with tops of adjacent pieces aligned.
- D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.
- E. Do not stretch resilient base during installation.

### 3.3 CLEANING AND PROTECTION

- A. Comply with manufacturer's written instructions for cleaning and protection of resilient products.
- B. Cover resilient products until Substantial Completion.

END OF SECTION 096513

## SECTION 096813 - TILE CARPETING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes modular, fusion-bonded or tufted, carpet tile to match existing.

#### 1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
  - 1. Laboratory Test Reports for Credit EQ 4: For carpet and installation adhesives, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Shop Drawings: Show the following:
  - 1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.
  - 2. Type of subfloor.
  - 3. Type of installation.
  - 4. Pattern of installation.
  - 5. Pattern type, location, and direction.
  - 6. Pile direction.
- C. Samples: For each exposed product and for each color and texture specified.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Product test reports.
- B. Sample warranty.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.

## 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II or Master II certification level.
- B. Fire-Test-Response Ratings: Where indicated, provide carpet tile identical to those of assemblies tested for fire response according to NFPA 253 by a qualified testing agency.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with CRI 104.

## 1.8 FIELD CONDITIONS

- A. Comply with CRI 104 for temperature, humidity, and ventilation limitations.

## 1.9 WARRANTY

- A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
  - 1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
  - 2. Failures include, but are not limited to, more than 10 percent edge raveling, snags, runs, dimensional stability, excess static discharge, loss of tuft bind strength, loss of face fiber, and delamination.
  - 3. Warranty Period: 10 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 CARPET TILE

- A. Products: Subject to compliance with requirements, provide the following:
  - 1. Per Utah Valley University standard carpet tile specification.
- B. Color & Pattern: Match Existing or per Utah Valley University standards.
- C. Fiber Content & Type: Match Existing or per Utah Valley University standards.
- D. Pile Characteristic & Thickness: Match Existing or per Utah Valley University standards.
- E. Yarn Twist, Count, & Density: Match Existing or per Utah Valley University standards.
- F. Stitches & Guage: Match Existing or per Utah Valley University standards.
- G. Surface Pile & Total Weight: Match Existing or per Utah Valley University standards.
- H. Primary Backing/Backcoating: Match Existing or per Utah Valley University standards.

- I. Secondary Backing: Match Existing or per Utah Valley University standards.
- J. Size: Match Existing or per Utah Valley University standards.
- K. Applied Soil-Resistance Treatment: Manufacturer's standard material.
- L. Antimicrobial Treatment: Manufacturer's standard material.
- M. Performance Characteristics: As follows:
  - 1. Appearance Retention Rating: Heavy traffic, 3.0 or Severe traffic, 3.5 according to ASTM D 7330 and to match Existing or per Utah Valley University standards.
  - 2. Critical Radiant Flux Classification: Not less than 0.45 W/sq. cm.
  - 3. Dry Breaking Strength: Not less than 100 lbf (445 N) according to ASTM D 2646.
  - 4. Tuft Bind: Not less than 8 lbf (36 N) according to ASTM D 1335.
  - 5. Delamination: Not less than 3.5 lbf/in. (15 N/mm) according to ASTM D 3936.
  - 6. Dimensional Tolerance: Within 1/32 inch (0.8 mm) of specified size dimensions, as determined by physical measurement.
  - 7. Dimensional Stability: 0.2 percent or less according to ISO 2551 (Aachen Test).
  - 8. Resistance to Insects: Comply with AATCC 24.
  - 9. Colorfastness to Crocking: Not less than 4, wet and dry, according to AATCC 165.
  - 10. Colorfastness to Light: Not less than 4 after 60 AFU (AATCC fading units) according to AATCC 16, Option E.
  - 11. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria, not less than 1-mm halo of inhibition for gram-negative bacteria, and no fungal growth, according to AATCC 174.
  - 12. Electrostatic Propensity: Less than 2 kV according to AATCC 134.
  - 13. Emissions: Provide carpet tile that complies with testing and product requirements of CRI's "Green Label Plus" program.
  - 14. Emissions: Provide carpet tile that complies with the product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.2 INSTALLATION ACCESSORIES

- A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.
- B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that complies with flammability requirements for installed carpet tile and is recommended by carpet tile manufacturer for releasable installation.
  - 1. Adhesives shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. Adhesives shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance. Examine carpet tile for type, color, pattern, and potential defects.
- B. Concrete Subfloors: Verify that concrete slabs comply with ASTM F 710.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Preparation: Comply with CRI 104, Section 6.2, "Site Conditions; Floor Preparation," and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile installation.
- E. Installation: Comply with CRI 104, Section 14, "Carpet Modules," and with carpet tile manufacturer's written installation instructions.
- F. Installation Method: Match Existing or per Utah Valley University standards.
- G. Maintain dye lot integrity. Do not mix dye lots in same area.
- H. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.
- I. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.
- J. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on finish flooring as marked on subfloor. Use nonpermanent, nonstaining marking device.
- K. Install pattern parallel to walls and borders.
- L. Perform the following operations immediately after installing carpet tile:
  - 1. Remove excess adhesive, seam sealer, and other surface blemishes using cleaner recommended by carpet tile manufacturer.
  - 2. Remove yarns that protrude from carpet tile surface.
  - 3. Vacuum carpet tile using commercial machine with face-beater element.
- M. Protect installed carpet tile to comply with CRI 104, Section 16, "Protecting Indoor Installations."

END OF SECTION 096813

SECTION 099113 - EXTERIOR PAINTING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes surface preparation and the application of paint systems on the following exterior substrates:
  - 1. Steel.
  - 2. Galvanized metal.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For each finish and for each color and texture required.
- C. Product List: Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.

1.3 QUALITY ASSURANCE

- A. MPI Standards:
  - 1. Products: Complying with MPI standards indicated and listed in "MPI Approved Products List."
  - 2. Preparation and Workmanship: Comply with requirements in "MPI Architectural Painting Specification Manual" for products and paint systems indicated.

1.4 EXTRA MATERIALS

- A. Furnish extra materials described below that are from same production run (batch mix) as materials applied and that are packaged for storage and identified with labels describing contents.
  - 1. Quantity: Furnish an additional 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

PART 2 - PRODUCTS

2.1 PAINT, GENERAL

- A. Material Compatibility:
  - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
  - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.
- B. Colors: As selected by Architect from manufacturer's full range.

## 2.2 METAL PRIMERS

- A. Alkyd Anticorrosive Metal Primer: MPI #79.

1. VOC Content: E Range of E1.

## 2.3 EXTERIOR ALKYD PAINTS

- A. Exterior Alkyd Enamel (Semigloss): MPI #94 (Gloss Level 5).

1. VOC Content: E Range of E1.

## 2.4 QUICK-DRYING ENAMELS

- A. Quick-Drying Enamel (Semigloss): MPI #81 (Gloss Level 5).

1. VOC Content: E Range of E1.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of work.
- B. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- C. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.
1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

### 3.2 PREPARATION AND APPLICATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.
- B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulants.
1. Remove incompatible primers and reprime substrate with compatible primers as required to produce paint systems indicated.
- C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- D. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- E. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

### 3.3 EXTERIOR PAINTING SCHEDULE

#### A. Steel Substrates:

1. Quick-Drying Enamel System: MPI EXT 5.1A.
  - a. Prime Coat: Quick-drying alkyd metal primer.
  - b. Intermediate Coat: Quick-drying enamel matching topcoat.
  - c. Topcoat: Quick-drying enamel (semigloss).
2. Alkyd System: MPI EXT 5.1D.
  - a. Prime Coat: Alkyd anticorrosive metal primer.
  - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
  - c. Topcoat: Exterior alkyd enamel (semigloss).

#### B. Galvanized-Metal Substrates:

1. Alkyd System: MPI EXT 5.3B.
  - a. Prime Coat: Cementitious galvanized-metal primer.
  - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
  - c. Topcoat: Exterior alkyd enamel (semigloss).

#### C. Exterior Gypsum Board Substrates:

1. Latex System: MPI EXT 9.2A.
  - a. Prime Coat: Exterior latex matching topcoat.
  - b. Intermediate Coat: Exterior latex matching topcoat.
  - c. Topcoat: Exterior latex (semigloss).

END OF SECTION 099113

## SECTION 099123 - INTERIOR PAINTING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes surface preparation and the application of paint systems on the following interior substrates:
  - 1. Concrete masonry units (CMU).
  - 2. Steel.
  - 3. Galvanized metal.
  - 4. Gypsum board.

#### 1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For each finish and for each color and texture required.
- C. Product List: Printout of current "MPI Approved Products List" for each product category specified in Part 2, with the proposed product highlighted.

#### 1.3 QUALITY ASSURANCE

- A. MPI Standards:
  - 1. Products: Complying with MPI standards indicated and listed in "MPI Approved Products List."
  - 2. Preparation and Workmanship: Comply with requirements in "MPI Architectural Painting Specification Manual" for products and paint systems indicated.

#### 1.4 EXTRA MATERIALS

- A. Furnish extra materials described below that are from same production run (batch mix) as materials applied and that are packaged for storage and identified with labels describing contents.
  - 1. Quantity: Furnish an additional 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

### PART 2 - PRODUCTS

#### 2.1 PAINT, GENERAL

- A. Material Compatibility:
  - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
  - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. Chemical Components of Field-Applied Interior Paints and Coatings: Provide products that comply with the following limits for VOC content, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24) and the following chemical restrictions; these requirements do not apply to primers or finishes that are applied in a fabrication or finishing shop:

1. Flat Paints and Coatings: VOC content of not more than 50 g/L.
2. Nonflat Paints and Coatings: VOC content of not more than 150 g/L.
3. Aromatic Compounds: Paints and coatings shall not contain more than 1.0 percent by weight of total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).
4. Restricted Components: Paints and coatings shall not contain any of the following:
  - a. Acrolein.
  - b. Acrylonitrile.
  - c. Antimony.
  - d. Benzene.
  - e. Butyl benzyl phthalate.
  - f. Cadmium.
  - g. Di (2-ethylhexyl) phthalate.
  - h. Di-n-butyl phthalate.
  - i. Di-n-octyl phthalate.
  - j. 1,2-dichlorobenzene.
  - k. Diethyl phthalate.
  - l. Dimethyl phthalate.
  - m. Ethylbenzene.
  - n. Formaldehyde.
  - o. Hexavalent chromium.
  - p. Isophorone.
  - q. Lead.
  - r. Mercury.
  - s. Methyl ethyl ketone.
  - t. Methyl isobutyl ketone.
  - u. Methylene chloride.
  - v. Naphthalene.
  - w. Toluene (methylbenzene).
  - x. 1,1,1-trichloroethane.
  - y. Vinyl chloride.

C. Colors: As selected by Architect from manufacturer's full range.

## 2.2 BLOCK FILLERS

A. Interior/Exterior Latex Block Filler: MPI #4.

1. VOC Content: E Range of E2.

### 2.3 PRIMERS/SEALERS

- A. Interior Latex Primer/Sealer: MPI #50.
  - 1. VOC Content: E Range of E2.
  - 2. Environmental Performance Rating: EPR 2.

### 2.4 METAL PRIMERS

- A. Rust-Inhibitive Primer (Water Based): MPI #107.
  - 1. VOC Content: E Range of E2.
  - 2. Environmental Performance Rating: EPR 2.

### 2.5 LATEX PAINTS

- A. Interior Latex (Semigloss): MPI #54 (Gloss Level 5).
  - 1. VOC Content: E Range of E2.
  - 2. Environmental Performance Rating: EPR 2.
- B. Interior Latex (Gloss): MPI #114 (Gloss Level 6, except minimum gloss of 65 units at 60 deg).
  - 1. VOC Content: E Range of E2.
  - 2. Environmental Performance Rating: EPR 2.
- C. Institutional Low-Odor/VOC Latex (Semigloss): MPI #147 (Gloss Level 5).
  - 1. VOC Content: E Range of E3.
  - 2. Environmental Performance Rating: EPR 3.

### 2.6 QUICK-DRYING ENAMELS

- A. Quick-Drying Enamel (Semigloss): MPI #81 (Gloss Level 5).
  - 1. VOC Content: E Range of E2.
- B. Quick-Drying Enamel (High Gloss): MPI #96 (Gloss Level 7).
  - 1. VOC Content: E Range of E2.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
  - 1. Masonry (Clay and CMU): 12 percent.

2. Gypsum Board: 12 percent.
- C. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- D. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.
  1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

### 3.2 PREPARATION AND APPLICATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
- B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulants.
  1. Remove incompatible primers and reprime substrate with compatible primers as required to produce paint systems indicated.
- C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- D. Painting Mechanical and Electrical Work: Paint items exposed in equipment rooms and occupied spaces including, but not limited to, the following:
  1. Mechanical Work:
    - a. Uninsulated metal piping.
    - b. Uninsulated plastic piping.
    - c. Pipe hangers and supports.
    - d. Tanks that do not have factory-applied final finishes.
    - e. Visible portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets.
    - f. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
    - g. Mechanical equipment that is indicated to have a factory-primed finish for field painting.
  2. Electrical Work:
    - a. Switchgear.
    - b. Panelboards.
    - c. Electrical equipment that is indicated to have a factory-primed finish for field painting.
- E. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- F. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

### 3.3 INTERIOR PAINTING SCHEDULE

1. Latex Over Sealer System: MPI INT 3.1A.
  - a. Prime Coat: Interior latex primer/sealer.

- b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex (semigloss).
  2. Institutional Low-Odor/VOC Latex System: MPI INT 3.1M.
    - a. Prime Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - b. Intermediate Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - c. Topcoat: Institutional low-odor/VOC interior latex (semigloss).
- B. CMU Substrates:
  1. Latex System: MPI INT 4.2A.
    - a. Prime Coat: Interior/exterior latex block filler.
    - b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex (semigloss).
  2. Institutional Low-Odor/VOC Latex System: MPI INT 4.2E.
    - a. Prime Coat: Interior/exterior latex block filler.
    - b. Intermediate Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - c. Topcoat: Institutional low-odor/VOC interior latex (eggshell).
- C. Steel Substrates:
  1. Quick-Drying Enamel System: MPI INT 5.1A.
    - a. Prime Coat: Quick-drying alkyd metal primer.
    - b. Intermediate Coat: Quick-drying enamel matching topcoat.
    - c. Topcoat: Quick-drying enamel (semigloss).
  2. Institutional Low-Odor/VOC Latex System: MPI INT 5.1S.
    - a. Prime Coat: Rust-inhibitive primer (water based).
    - b. Intermediate Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - c. Topcoat: Institutional low-odor/VOC interior latex (semigloss).
- D. Galvanized-Metal Substrates:
  1. Latex System: MPI INT 5.3A.
    - a. Prime Coat: Cementitious galvanized-metal primer.
    - b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex (semigloss).

2. Latex Over Waterborne Primer System: MPI INT 5.3J.
    - a. Prime Coat: Waterborne galvanized-metal primer.
    - b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex (semigloss).
  3. Institutional Low-Odor/VOC Latex System: MPI INT 5.3N.
    - a. Prime Coat: Waterborne galvanized-metal primer.
    - b. Intermediate Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - c. Topcoat: Institutional low-odor/VOC interior latex (semigloss).
- E. Gypsum Board Substrates:
1. Latex System: MPI INT 9.2A.
    - a. Prime Coat: Interior latex primer/sealer.
    - b. Intermediate Coat: Interior latex matching topcoat.
    - c. Topcoat: Interior latex (semigloss).
  2. Institutional Low-Odor/VOC Latex System: MPI INT 9.2M.
    - a. Prime Coat: Interior latex primer/sealer.
    - b. Intermediate Coat: Institutional low-odor/VOC interior latex matching topcoat.
    - c. Topcoat: Institutional low-odor/VOC interior latex (semigloss).

END OF SECTION 099123

#### 1.01 SECTION INCLUDES

- A. Pipe materials.
- B. Fittings, unions, flanges, and couplings.
- C. Welding fittings.
- D. Pipe sleeves and seals.
- E. Motor starters
- F. Factory-wired panels
- G. Wiring
- H. Equipment guards.
- I. Tie rods.
- J. Pipe joining methods.
- K. Cleaning and protection.
- L. Leakage tests.
- M. Piping schedules.

#### 1.02 SUBMITTALS

- A. Quality assurance data: Certified records, indicating that procedures used and welding operators employed are in compliance with codes referenced in article "Quality Assurance."

#### 1.03 QUALITY ASSURANCE

- A. Regulatory requirements:
  - 1. Piping construction criteria shall conform to requirements of ANSI B31.9 as applicable. Work shall also comply with applicable state and local codes.
- B. Certifications: New materials and equipment shall bear manufacturer's name, model number, or other identification marking.
- C. Standard product shall be of latest design with published properties of manufacturer regularly engaged in production of specified material or equipment for minimum 5 years (unless exempted by Engineer).
- D. Unless otherwise indicated, equipment of same type in same room shall match color, finish, and design.
- E. Standardization: Unless otherwise submitted to and accepted by Engineer, equipment and its devices shall be of same manufacturer; or devices must be approved and warranted by equipment manufacturer.

#### 1.04 COORDINATION

- A. Coordinate with all trades regarding location and size of pipes, equipment, ducts, openings, light fixtures, and other similar items mutually located in same or adjacent spaces.
- B. Make minor modifications in Work required by interferences (structural, work of other trades) following notification to Engineer.
- C. Order of priorities:
  1. Recessed lighting fixtures.
  2. Ductwork system.
  3. Plumbing waste lines, downspouts, and vents.
  4. Refrigeration lines.
  5. Sprinkler lines.
  6. Heating lines.
  7. Plumbing water lines.
  8. Electrical conduit.
  9. Control air lines or conduit.
- D. Mechanical and electrical coordination:
  1. Power wiring includes:
    - a. Circuitry carrying electrical energy from panelboard or other central distribution point to motor through motor starter protection devices and disconnect, or to main terminals in factory-wired panel (FWP); and final connections.
    - b. Additional conduit and wiring to remote devices indicated on Drawings.
    - c. Refer to Division 26.
  2. Starters and disconnects:
    - a. Furnish and install where indicated on Drawings.
    - b. Refer to Division 26.

#### 1.05 OPENINGS, SLEEVES, AND CHASES

- A. Each equipment and piping supplier shall provide:
  1. Opening and hole information through floors, walls, and roofs for its work; including all pipe, conduit, duct sleeves, inserts, hangers, plates, and flashing and sealant for those openings and holes.
  2. Exact information to others as to size, depth, and location of such openings before construction is in place; and delivery and setting in place of boxes, sleeves, inserts, and forms for its work in time for installation in all locations.
  3. Cutting, patching, and restoration to accommodate Contractor's failure to provide specified data in time for openings to be left or to accommodate boxes, sleeves, inserts, or forms after construction.
  4. Skilled craftsman to cut, patch, rebuild, restore, replace, refinish, and repaint new construction that has been cut, disturbed, or marred to original new condition; for installation of new, exposed, concealed, underground, or underfloor work; for admission of new work and equipment; for installation of new equipment and new work in new construction; for complete restoration of pipe, duct, or equipment covering disturbed or marred by its personnel.
  5. Cutting:
    - a. Use core drill or radial saw.
    - b. Cutting of lintels, structural steel, or reinforcement is not permitted.

## PART 2 PRODUCTS

### 2.01 DESIGN REQUIREMENTS

- A. Plumbing, heating, ventilating and air conditioning, and temperature control designs are based on specified or scheduled equipment manufacturers.
- B. Transformers, conduit, disconnects, breakers, fuses, and wire sizes are selected on basis of scheduled or specified equipment.

- C. Increased current requirements requiring larger wire, additional wires, larger conduit, starters, breakers, or switches not indicated on Drawings to accommodate alternate or substitute manufacturer's equipment shall be provided by supplier furnishing substituted equipment.

## 2.02 PIPE MATERIALS

- A. Pipe materials shall be as specified herein and in Mechanical Standards bound at end of Project Manual. No asbestos shall be used. If pipe wall thickness specified is not available, use next heavier wall.

## 2.03 COPPER TUBING

- A. Materials shall be rated by AHU manufacturer as suitable for refrigeration service.

## 2.04 FITTINGS - GENERAL

- A. Material, wall thickness, and pressure class: As specified in article "Pipe Materials," unless otherwise noted.
- B. Use long radius fittings, except where space limitations require short radius.
- C. Provide dielectric unions at connections between ferrous and nonferrous piping and at connections of nonferrous piping to ferrous equipment.
- D. For soil, waste, and vent piping use 45° Y, long sweep quarter, eighth or sixteenth bends, or combinations of these.

## 2.05 UNIONS, FLANGES, AND COUPLINGS

- A. Pressure class, material, and facing: As specified in article "Pipe Materials."
- B. Pipe size 2" and smaller: Malleable iron unions for threaded ferrous piping; cast bronze or wrought copper unions for copper piping with soldered or brazed joints.
- C. Pipe size 2-1/2" and larger: Forged steel welding neck or slip-on flanges for ferrous piping; bronze flanges for copper piping; 1/8" thick preformed synthetic fiber gaskets, Garlock "Blue-Gard 3000," or equal.

## 2.06 WELDING FITTINGS

- A. Material and wall thickness: As specified in article "Pipe Materials."
- B. Use welding tees for socket-welded piping for field-fabricated branch tees in butt-weld end piping.
- C. Nozzle-welded branches or "Weldolets" and "Threadolets" will be permitted instead of butt welding tees for shop-fabricated black steel piping, provided that such nozzles are fabricated in accordance with ASME B31.9. Use tees for branches in nonblack piping.
- D. Mitering of pipe to form elbows, notching straight pipe to form tees, and similar construction will not be acceptable for pressure piping except where specifically permitted in Mechanical Standards.

## 2.07 PIPE SLEEVES

- A. Provide sleeves for piping passing through building structure, except where otherwise shown on Drawings.

- B. Through footings: Cast iron.
  - C. Other locations below grade: Cast iron or standard weight wrought iron pipe.
  - D. Above grade: Steel pipe, sheet steel not lighter than 16 U.S. Standard gage, or fiber with 1/4" minimum wall thickness or thermoplastic construction Link-Seal "Century-Line," or equal.
  - E. Size:
    - 1. Foundations and footings: 4" larger than carrier pipe.
    - 2. Walls and floors: 2" larger than carrier pipe.
    - 3. Floors: Extend 4" above floor.
- 2.08 PIPE SLEEVE SEALS
- A. Rubber expandable seals as manufactured by Link-Seal, or equal.
  - B. Fire-rated floors and walls: Link-Seal "Pyro-Pac," or equal.
- 2.09 PIPE MARKERS
- A. Type: SNA "Setmark," snap-on type with arrows as manufactured by Seton, or equal.
  - B. Wording and color combinations: ANSI A13.1.
- 2.10 MOTORS AND STARTERS
- A. Motors 1/2 hp and less shall be ODP squirrel cage induction motors in NEMA frames suitable for operations on 120 volt ac, single-phase, 60 Hz, unless noted otherwise.
  - B. Motors 3/4 hp and larger shall be ODP squirrel cage induction motors in NEMA frames suitable for operation on 208 volt ac, 3-phase, 60 Hz, unless noted otherwise.
  - C. Motors shall have starting and torque characteristics compatible with driven equipment.
  - D. Motors shall have 1.15 service factor rated at 200°F ambient temperature (Class B insulation) with 100°F temperature rise.
- 2.11 FACTORY-WIRED PANEL (FWP)
- A. Provide as part of equipment package; including starters, interconnecting wiring, including field wiring, between panel and associated equipment disconnects (except for disconnects indicated on Drawings on line side of FWP), control transformers, integral control devices, and pre-wired controls; ready for final control and power connections.
  - B. When motors or controls are not indicated on Drawings, motors and controls shall be part of FWP equipment package.
- 2.12 WIRING
- A. Provide wiring not indicated on Drawings including electrically operated wall thermostats, flow switches, control modules, smoke detectors part of specified HVAC control systems, and electrical conduit, wire and connections related to mechanical equipment controls.
  - B. Automatic temperature control wiring for control work specified in Section 23 09 13 shall be furnished and installed by control manufacturer.
- 2.13 GUARDS

- A. Provide guards for drives on equipment that are belt, chain, or gear-driven or with rotating elements such as shaft couplings, sheaves, and shafts with projecting set screws and keys.
- B. Belt guards shall enclose both pulleys and belts on exposed sides; 14-gage galvanized steel top and bottom with expanded or solid metal front locked into rim.
- C. Assembly shall be supported by supplementary steel. Provide for greasing, oiling, adjusting, and checking of equipment.
- D. Provide coupling guards on direct connected units.
- E. Comply with UL safety requirements, and State of Utah Safety code.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION - GENERAL**

- A. Work provided shall be complete and operable, and shall include required accessories, specialties, fastenings, supports, auxiliary building steel, and similar items.
- B. Determine required location, arrangement, and quantities of equipment and materials from Drawings.
- C. Equipment shall be installed in accordance with manufacturers' recommendations.
- D. Power wiring and interconnection of electrical accessories specified under this Division will be performed under Division 26 unless otherwise indicated.
- E. Install piping as shown on Drawing and as specified. Hot and cold potable water piping and sanitary and storm drainage systems shall comply with state and local plumbing codes.
- F. Modify pipe routing as required to clear building structure, openings, lights, ducts, and work of other trades.
- G. Route piping parallel to building lines.
- H. Provide sufficient unions and flanges to permit removal of equipment.
- I. Spacing of piping shall be adequate to permit servicing valves and specialties and replacing sections of pipe.
- J. Slope pipe to permit complete draining. Install drain valves at low points.
- K. Provide nuts, bolts, gaskets, and washers for complete and proper installation.

#### **3.02 PIPE JOINING METHODS**

- A. Comply with Mechanical Standards listed under article "Pipe Materials" and with requirements of ANSI B31, unless otherwise indicated.
- B. Threaded joints:
  - 1. Clean-cut threads, ream pipe ends, and remove burrs.
  - 2. Apply suitable lubricating, noncorrosive, flexible pipe joint compound to male threads only.
- C. Flanged joints:

1. Clean mating surfaces of flanges.
2. Install gasket and tighten bolts evenly.

D. Solder joints:

1. Cut tube square, ream end, and remove burrs.
2. Clean tube end and fitting socket to bright metal.
3. Apply flux to both surfaces, preheat, and feed solder until joint space is filled.
4. Wipe off excess solder, leaving small fillet, remove excess flux.

E. Weld joints:

1. Cut pipe square, and prepare pipe ends for welding as required by ANSI B31.
2. Workmanship shall conform to details and requirements of ANSI B31.

F. Brazed joints:

1. Cut tube square and prepare for brazing as required by ANSI B31.
2. Workmanship shall conform to details and requirements of ANSI B31.
3. Qualifications of brazing procedures and brazing operators shall be in accordance with Part C, Section IX, ASME Boiler and Pressure Vessel Code.

G. Other joints and jointing methods: In accordance with Pipe Material Schedule and Mechanical Standards.

### 3.03 LEAKAGE TESTS

- A. Notify Engineer and Owner of intent to test piping at least 1 week prior to test. Test in presence of Engineer and Owner, unless notified otherwise.
- B. Refrigeration piping:
  1. Joints and connections shall be examined for apparent faults before testing.
  2. Test at not less than lower of design pressure or setting of pressure relief device protecting system.
  3. Test medium shall be nitrogen gas or refrigerant of type to be used in equipment. Use halide leak detector to locate small leaks.
- C. Vents and gravity drainage piping: Cap discharge, fill with water, and check for leaks.
- D. Other piping: Test hydrostatically, in accordance with ANSI B31.
- E. Provide pumps, compressors, meters, gages, piping, fittings, accessories, and labor required to conduct tests.
- F. Isolate equipment that may be damaged by test pressure.
- G. Refit joints indicating leakage, replace defective pipe, fittings, and accessories.

### 3.04 CLEANING AND PROTECTION

- A. Remove foreign material from pipes before erection.
- B. Close ends of partially erected systems.
- C. Remove temporary preservative coatings from valves and accessories.
- D. Flush or otherwise clean systems after erection.
- E. Prior to conducting final performance test Contractor shall verify that strainers are clean.

- F. Contractor shall be responsible for malfunctioning of pumps, valves, controls, or other equipment due to presence of foreign material. Contractor shall clean, repair or replace malfunctioning equipment at no cost to Owner.

3.05 PIPE IDENTIFICATION

- A. Provide pipe markers on new piping exposed in equipment rooms, accessible pipe shafts, unfinished basement areas, unfinished storage rooms, janitor's closets, tunnels, and other areas where directed.
- B. Install markers on both horizontal and vertical section of pipe at points where pipes pass through walls, floor, or ceiling, and at each valve. In tunnels, markers shall be no greater than 20' apart, or 1 marker minimum for sections less than 20'.

3.06 EXPOSED INTERIOR PIPING SCHEDULE

Service	Pipe	Mechanical Standard No.
Fire protection 3/4" through 20"	ASTM A53 black steel piping accessories in accordance with NFPA 13	M-1712
Chilled water and hot water  1/2" and larger	ASTM B306 hard-drawn copper, Type K	M-1725 or M-1726
Coil condensate drains 2" and smaller	ASTM B306 hard-drawn copper or ASTM A53 galvanized steel or CISPI 301 no-hub cast iron	M-1772 or M-1725

END OF SECTION

PIPE	MATERIAL, ASTM	A53 B TYPE E OR S			
	MIN PIPE SIZE TO BE USED	3/4"			
	PIPE SIZES (INCLUSIVE) AND MIN WALL THICKNESS	3/4" - 20"		STANDARD WEIGHT	
		24"		EXTRA STRONG	
JOINTS	TYPE	BOLTED CLAMP-TYPE COUPLING WITH GROOVED END LOCK; VICTAULIC, OR EQUAL			
	COUPLINGS	MALLEABLE IRON, ASTM A47 GRADE 32510			
	GASKETS	PREFORMED SYNTHETIC RUBBER			
	BOLTING	TRACK BOLTS AND NUTS, ASTM A183			
	PIPE SIZES (INCLUSIVE)	3/4" - 1 1/2"	2" - 8"	10" - 24"	
	VICTAULIC STYLE	77	75	77	
FITTINGS	TYPE	FULL FLOW, STREAMLINED, GROOVED ENDS			
	MATERIAL, ASTM	A47 GRADE 32510, MALLEABLE IRON			
	PRESSURE CLASS (MIN)	150			
VALVES - RISING STEM	PIPE SIZE (INCLUSIVE)	3/4" - 2"		2 1/2" - 12" (1)	
	BODY MATERIAL, ASTM	B62 BRONZE		A126 B CAST IRON	
	PRESSURE CLASS, MSS/ANSI	150		125	
	BONNET TYPE	UNION		BOLTED	
	INTERNALS AND TRIM	(2)		BRONZE	
	VALVE ENDS	(3)		(4)	

NOTES:

- (1) FOR VALVES LARGER THAN 12", SEE SPECIFICATIONS.
- (2) TFE DISCS FOR GLOBE VALVES; ALL-BRONZE TRIM FOR GATE VALVES.
- (3) USE GROOVED-END VALVES OR SUPPLY THREADED NIPPLES HAVING GROOVED-END ADAPTERS.
- (4) USE GROOVED-END VALVES OR PROVIDE 150 LB SLIP-ON STEEL COMPANION FLANGES WITH FLAT GASKET FACES.

2 -REVS & CADD	TRK	SJS		5/13/94
1 -GENERAL	CAH	RBD		4-2-86
REVISIONS	DWN	APVD	APVD	DATE



DESIGNED _____
DRAWN <u>D.L.</u>
CHECKED <u>H.L.G.</u>
APPROVED <u>H.L.G.</u>
APPROVED <u>R.B.D.</u>
DATE <u>9-15-70</u>

MECHANICAL STANDARD  
PIPING DESIGN TABLE

GENERAL SERVICE PIPING  
CLASS ST150V  
150 PSIG 180°F

SCALE	NONE
NO.	REV.
M-1712	2

TUBING	MATERIAL, ASTM	B88 SEAMLESS, HARD DRAWN COPPER	
	MAXIMUM SIZE	8" (NOMINAL)	
	TUBING SIZE (INCLUSIVE) AND MIN WALL THICKNESS	THRU 6"	TYPE K
		8"	TYPE L
JOINTS	TYPE OF JOINT	SOLDERED; FLANGED WHERE REQUIRED	
	SOLDER, ASTM	B32 GRADE 95TA (95-5 TIN ANTIMONY) NOTE 3	
FITTINGS	TYPE	CAST (ANSI B16.18) OR WROUGHT (ANSI B16.22) COPPER STREAMLINE; NIBCO, OR EQUAL	
	CONNECTIONS TO FERROUS PIPING OR EQUIPMENT (EXCLUSIVE OF DRAIN PIPING)	DIELECTRIC UNIONS OR FLANGES; "EPCO", OR EQUAL	
VALVES - RISING STEM	PIPE SIZE (INCLUSIVE)	THRU 3"	4" - 8"
	TYPE	GLOBE WITH BRONZE DISC; GATE WITH WEDGE DISC; BUTTERFLY (2)	GLOBE WITH BRONZE DISC; GATE WITH WEDGE DISC (1); BUTTERFLY (2)
	BODY MATERIAL, ASTM	B62 BRONZE	A126 B CAST IRON
	PRESSURE CLASS, MSS/ANSI	150	125
	BONNET TYPE	UNION	BOLTED
	ENDS	SOLDER JOINT OR SCREWED W/ ADAPTER FITTINGS	FLANGED

NOTES:

- (1) NON-RISING STEM WITH INDICATOR MAY BE FURNISHED WHEN RISING STEM VALVES ARE NOT AVAILABLE.
- (2) CAST IRON FLANGED BODY, ONE PIECE SPOOL TYPE RUBBER SEAT EXTENDING THROUGH VALVE BODY AND OVER FLANGE FACE, BRONZE DISC.
- (3) FOR POTABLE WATER SERVICE SHALL BE SILVER SOLDER.

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					 <b>Stanley Consultants INC.</b>				
I -REVS & CADD	TRK	SJS		5/13/94					
REVISIONS	DWN	APVD	APVD	DATE					
DESIGNED _____	<b>MECHANICAL STANDARD PIPING DESIGN TABLE</b>				<b>GENERAL SERVICE PIPING CLASS HCUI25 125 PSIG                      220°F</b>		SCALE	NONE	
DRAWN <u>      C.R.H.      </u>							NO.	M-1725	
CHECKED <u>      J.L.H.      </u>									
APPROVED <u>      H.L.G.      </u>									
APPROVED _____									
DATE <u>      4-24-67      </u>									

TUBING	MATERIAL, ASTM	ASTM B88 SEAMLESS, SOFT ANNEALED COPPER (1)		
	MAXIMUM SIZE	2 1/2" (NOMINAL)		
	TUBING SIZE (INCLUSIVE) AND MIN WALL THICKNESS	ALL	TYPE K (HEAVY)	
JOINTS	TYPE	FLARED TUBE		
FITTINGS	TYPE	ANSI B16.26 FLARED TUBE W/ FLARED NUT FOR EACH TUBE END; NIBCO, OR EQUAL		
	MATERIAL, ASTM	B62 ALLOY C83600		
	CONNECTIONS TO FERROUS PIPING OR EQUIPMENT	DIELECTRIC UNIONS; "EPCO", OR EQUAL		
VALVES	TYPE	RISING STEM GLOBE BODY STOP VALVE (2)	KEY OPERATED ORI-CORP CORPORATION VALVE; MUELLER, OR EQUAL	KEY OPERATED ORISEAL CURB VALVE (3); MUELLER, OR EQUAL
	BODY MATERIAL, ASTM	B62 BRONZE	BRONZE	BRONZE
	PRESSURE CLASS, ANSI	150	175 --	175 --
	INTERNALS	TFE DISC	--	INVERTED TAPER PLUG
	ENDS	FLARED OR SCREWED WITH ADAPTOR FITTINGS	THREADED INLET, FLARED TUBE OUTLET	FLARED TUBE
	MISCELLANEOUS	DRAIN ON DISCHARGE SIDE	MULTIPLE TYPE WHERE REQUIRED TO SUIT MAIN PIPE SIZE	GASKETED CAP AND BASE

NOTES:

- (1) THIS SPECIFICATION APPLIES TO FLARED-JOINT COPPER TUBING FOR PLUMBING INCLUDING UNDERGROUND SERVICE PIPING.
- (2) FOR INDOOR OR ABOVE GROUND SERVICE.
- (3) PROVIDE SELF SUPPORTED ADJUSTABLE SERVICE BOX.

3 -REVS & CADD	TRK	SJS		9-16-94
2 -GENERAL	CAH	RBD		4-2-86
1 -VALVE END	CAH	JAN		12-23-80
REVISIONS	DWN	APVD	APVD	DATE



DESIGNED _____
DRAWN <u>C.R.H.</u>
CHECKED <u>J.L.H.</u>
APPROVED <u>H.L.G.</u>
APPROVED <u>R.B.D.</u>
DATE <u>4-24-67</u>

MECHANICAL STANDARD  
PIPING DESIGN TABLE

GENERAL SERVICE PIPING  
CLASS SCUI25  
125 PSIG                      220°F

SCALE	NONE	
NO.	M-1726	REV.
		3

PIPE	MATERIAL, ASTM	B306 COPPER
	SIZES (INCLUSIVE)	1 1/4" - 6"
	MINIMUM THICKNESS	ASTM STANDARD
JOINTS	TYPE	SOLDERED
	SOLDER	ASTM B32, GRADE 95TA (95-5 TIN-ANTIMONY)
FITTINGS	TYPE	ANSI B16.23 DWV

NOTES:

(1) FOR ABOVE GROUND USE ONLY.

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1 -REVS & CADD	TRK	SJS		9-14-94
REVISIONS	DWN	APVD	APVD	DATE



Stanley Consultants INC.

DESIGNED <u>    R.J.D.    </u>	MECHANICAL STANDARD PIPING DESIGN TABLE	SOIL, WASTE AND VENT PIPING CLASS SP-CU DRAINAGE SERVICE ONLY	SCALE	NONE
DRAWN <u>    J.L.H.    </u>			NO.	REV.
CHECKED <u>    H.L.G.    </u>				
APPROVED _____				
APPROVED _____				
DATE <u>    4-24-67    </u>			M-1772	1

**1.01 SECTION INCLUDES**

- A. Gate valves.
- B. Ball valves.
- C. Butterfly valves.
- D. Swing check valves.
- E. Silent check.
- F. Calibrated balance valves.
- G. Pressure bypass valve.
- H. Vent caps.

**1.02 QUALITY ASSURANCE**

- A. International Plumbing Code.
- B. International Mechanical Code.

**PART 2 PRODUCTS****2.01 ACCEPTABLE MANUFACTURERS**

- A. Valves meeting the requirements specified as manufactured by Nibco, Clow, DeZurik, Trerice, Watts, Cash Acme, MKM Valve Co., Doves Corporation, or Bell & Gossett ITT.
- B. Wherever possible, provide valves of same manufacturer throughout.
- C. Manufacturer's name and pressure rating shall be clearly marked on outside of valve body.

**2.02 GATE VALVES**

- A. 2" or smaller:
  - 1. Body: Threaded ASTM B62 bronze.
  - 2. Bonnet: Union.
  - 3. Stem: Rising.
  - 4. Pressure class: 150 psig.
  - 5. Packing: \*TFE impregnated nonasbestos fibers.\* Aramid fibers with graphite.\*
  - 6. Manufacturer: Nibco Model T-134, or equal.
- B. 2-1/2" or larger:
  - 1. Body: Flanged OS&Y iron.
  - 2. Solid bronze wedge, \*Cast iron wedge with bronze face rings,\* rising stem.
  - 3. Pressure class: 125 psi water.
  - 4. Internals: Renewable bronze.
  - 5. Packing: \*Graphite impregnated nonasbestos fibers.\*\* Aramid fibers with graphite.\*
  - 6. Manufacturer: Nibco Model F-617-0, or equal.
- C. Cast steel:
  - 1. Service: High pressure steam (90 psig).
  - 2. Body: Cast steel, OS&Y, butt-welded connection.

3. Pressure class: 150 psi.
4. Internals: Chromium-steel with stellite faced seats.
5. Packing: Graphite impregnated nonasbestos fibers.
6. Manufacturer: Nibco Model CS-103-U, or equal.

### 2.03 BALL VALVES

- A. Size: 1-1/4" through 2".
- B. Body: Bronze-threaded, 2-piece construction.
- C. Ball and stem: Bronze.
- D. Seat and seals: Teflon.
- E. Working pressure: 125 psig.
- F. Manufacturer: Nibco Model T-580-Y, or equal.

### 2.04 BUTTERFLY VALVE

- A. Size: 2" through 4".
- B. Body: Ductile iron, lug-style.
- C. Disc: Aluminum bronze.
- D. Stem: Type 416 stainless steel.
- E. Liner: EPDM.
- F. Working pressure: 200 psig.
- G. Operator: Hand lever with multiposition, positive locking device.
- H. Manufacturer: Nibco Model LD-2000, or equal.

### 2.05 SWING CHECK VALVES

- A. 2" and smaller:
  1. Body: Threaded bronze, ASTM B62.
  2. Bonnet: Screwed bronze, ASTM B62.
  3. Seat: Integral bronze.
  4. Disc: TFE
  5. Working pressure: 125 psig.
  6. Manufacturer: Nibco Model T-413, or equal.
- B. 2-1/2" and larger:
  1. Body and bonnet: Flanged, cast iron, ASTM A395.
  2. Seat: Bronze, ASTM B61.
  3. Disc: Bronze, ASTM B61.
  4. Working pressure: 150 psig.
  5. Manufacturer: Nibco Model F-938-31, or equal.

## 2.06 SILENT CHECK

- A. Body: Cast iron, wafer-type.
- B. Plate and flappers: Bronze.
- C. Torsion spring: Stainless steel.
- D. Seat: Bronze, replaceable.
- E. Working pressure: 250 psig.
- F. Manufacturer: Bell & Gossett ITT Model NS.

## 2.07 CALIBRATED BALANCE VALVES

- A. Size: 1/2" to 3".
- B. Body: Threaded bronze.
- C. Plug: Bronze with precision-machined orifice, indicating pointer, calibrated nameplate, and pressure gage tappings. Furnish additional isolation valve downstream of calibrated balance valve where equipment may be disconnected and removed for servicing.
- D. Seals: O-ring.
- E. Working pressure: 125 psig.
- F. Manufacturer: Bell & Gossett ITT Model Circuit Setter, or equal.

## 2.08 GAGE COCKS

- A. Size: 1/4" NPT.
- B. Body: Brass.
- C. Core: Bronze.
- D. Cock: T-handle.
- E. Working pressure: 300 psi.
- F. Manufacturer: Trerice Model 865-1, or equal.

## 2.09 PRESSURE BYPASS VALVE

- A. Body: Threaded ASTM B62, bronze.
- B. Diaphragm: Stainless steel.
- C. Seat: Stainless steel.
- D. Range of adjustment: 5 to 50 psi.
- E. Manufacturer: Cash Acme Type FR, or equal.

**2.10 BACKFLOW PREVENTER**

- A. Body: Screwed, bronze.
- B. Working parts: Stainless steel.
- C. Manufacturer: Watts Model No. 9D, or equal.

**2.11 VENT CAPS**

- A. Service: Gasoline, fuel oil.
- B. Body: Aluminum, open-type.
- C. Screen: 40-mesh brass.
- D. Manufacturer: Dover Corporation, OPW Division Model OPW 23, or equal.

**2.12 TAPPING VALVE**

- A. Service: Chilled water.
- B. Type: Nonrising stem, gate.
- C. Body: Cast iron with bitumastic coating.
- D. Pressure class: 200 psi working pressure.
- E. Trim: Bronze.
- F. Wedge: Bronze, solid-type.
- G. Accessories:
  - 1. Valve box.
  - 2. Valve wrench.
  - 3. Lock cover.
- H. Manufacturer: Clow Corporation Model F-5093, or equal.
- I. Manufacturer: Hoffman Specialty ITT Model Series 2000, or equal.

**PART 3 EXECUTION****3.01 INSTALLATION**

- A. Install valves with stems upright or horizontal, not inverted.
- B. Install gate valves for shut-off and isolating service, to isolate equipment, part of systems or vertical risers.
- C. Install globe valves for control device or meter bypass.
- D. Provide silent check valves on the discharge of water circulation pumps.
- E. Use butterfly valves in heating and chilled water systems interchangeably with gate and globe valves 2-1/2" and larger.

- F. Use ball valves in heating, chilled water, and potable water systems interchangeably with gate and globe valves 2" and smaller.
- G. Use gas cocks for gas service.
- H. Use calibrated balance valves in water systems for throttling service. Install in discharge piping from circulation pumps.
- I. Install automatic fill valves in water supply to heating and chilled water systems. Install with isolation and bypass valves.
- J. Install backflow preventers in cross connections between potable and nonpotable water systems.
- K. Install gage cocks across pumps and other pieces of equipment where indicated on Drawings.
- L. Install indicator post gate valve provided under Section 21 00 00 in main fire protection line where indicated on Drawings.
- M. Install automatic knife gate valve at heat recovery chiller, standby chilled water supply to chiller primary circuit, and at steam inlet to primary heating circuit steam to water condenser. Normal valve position shall be as indicated on Drawings.
- N. Install pressure bypass valve between supply and return mains on systems employing 2-way valves. Select for flow of 1 gal/min per pump nameplate horsepower at a 10% rise in static pressure above that scheduled for associated pump.

END OF SECTION

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Piping specialty items including expansion tanks, strainers, relief valve, steam traps, air separators, suction diffusers, vacuum breakers, orifice flow meters, flexible hose sections, and swivel joints.

## 1.02 INFORMATIONAL SUBMITTALS

- A. Shop Drawings. Data shall include:
  1. Manufacturer.
  2. Model.
  3. Application.
  4. Materials of construction.
  5. Pressure rating (pressure and vacuum).
  6. Temperature rating.
  7. Bending radius.

## 1.03 QUALITY ASSURANCE

- A. Expansion tanks and air separator units shall be stamped with "U" symbol denoting compliance with ASME paragraph V-69, Section VIII, Construction of Unfired Pressure Vessels.

**PART 2 PRODUCTS**

## 2.01 TAPPED SADDLES

- A. Location: Welding Shop.
- B. Type: For cast iron pipe, type which complete encircles pipe and ensures watertight connection using molded rubber gasket.
- C. Manufacturer: Powerseal Pipeline Products Model 3418, or equal.

## 2.02 GAGE TAPS

- A. Type: Brass-needle type.
- B. Pressure: 300 psig.
- C. Manufacturer: Trerice Model 735-2, or equal.

## 2.03 PIPELINE STRAINERS

- A. Location: Welding Shop, AH Coils, Reheat coils, & Fan Coils.
- B. Type: "Y" type.
- C. Strainer basket: Monel; suitable for water service intended.
- D. Size:
  1. 2" and smaller: Bronze body, 125 psi construction, screwed ends, removable plug screen retainer.
  2. 2-1/2" and larger: Cast iron body, 125 psi construction, flanged ends, bolted screen retainer, off-center blow down connection, piped and valved.

## 2.04 THERMOMETER SOCKETS

- A. Material: Type 304 stainless steel, threaded 3/4" NPT.
- B. Length: Suitable for pipe diameter with extended necks as required for pipe insulation.
- C. Manufacturer: Ashcroft, Marsh, Taylor, Trerice, Weiss, or equal.

## 2.05 PUMP SUCTION DIFFUSERS

- A. Body: 150 psig, cast iron, with inlet vanes and diffuser; strainer-orifice cylinder.
- B. Strainer: With no less than 5 times cross sectional area of pump suction area. Disposable fine mesh start-up strainer with each unit.
- C. Adjustable support foot.

## 2.06 VACUUM BREAKERS

- A. Body: ASTM B62, brass, 300 psig working pressure at 365°F.
- B. Ball: Steel.
- C. Seal: Viton.
- D. Manufacturer: Johnson Corp., Model VB8, or equal.

## 2.07 ORIFICE PLATE FLOW METERS

- A. Body: Cast iron or aluminum, 125 psi working pressure.
- B. Companion flanges: Threaded 2" and smaller, butt welded 2-1/2" and larger, complete with pressure taps, bolts, nuts, gaskets, and jack screws.
- C. Furnish meter for balancing and turn meter over to Owner after final calibration.
- D. Venturi meters otherwise meeting this Specification may be used instead of orifice plate flow meters.

## 2.08 AIR VENTS

- A. Location: As detailed.
- B. Type: Manual.
- C. Manufacturer: Dole Model No. 9, or equal.

## 2.09 RELIEF VALVES

- A. ASME-rated direct spring-loaded type, lever-operated, nonadjustable factory set discharge pressure.
- B. Provide relief valves on pressure tanks, low pressure side of reducing valves, heating converters, and expansion tanks.
- C. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

**2.10 FLEXIBLE HOSE SECTIONS**

- A. Size: 1-1/4" through 4".
- B. Construction: White, seamless, nitrile tube and reinforcement of multiple plies of polyester with helix wire with gray, 1-piece EPDM cover.
- C. Vacuum rating: Full.
- D. Maximum working pressure: 150 psi.
- E. Connections: Stainless steel, female on each hose end; rigid cam and groove O.P.W. type, quick disconnects. Provide matching threaded male fittings at each end for hard piping.
- F. Manufacturer: Titan Model SW-430, or equal.

**PART 3 EXECUTION****3.01 TAPPED SADDLES**

- A. Install watertight to supply and return chilled water main as indicated on Drawings and in accordance with manufacturer's instructions.

**3.02 EXPANSION TANKS**

- A. Install expansion tanks as indicated on Drawings and as scheduled.

**3.03 AIR SEPARATORS**

- A. Install air separators of size and type shown on Drawings and scheduled.
- B. Install air separators on suction side of pump.
- C. Provide a valved blowdown connection and extend to nearest floor drain.

**3.04 GAGE TAPS**

- A. Install gage taps as indicated to isolate gages from systems served.

**3.05 PIPELINE STRAINERS**

- A. Install strainers as indicated on Drawings and as detailed.
- B. Install strainers in steam and water systems on entering side of automatic valves.
- C. Install strainers in water systems on entering side of pumps.
- D. Extend drain piping from blowoff connections to nearest floor drains.

**3.06 THERMOMETER SOCKETS**

- A. Install thermometer sockets at each point of temperature measurement for visual indication, automatic sensing for control, or remote measurement or indication.

**3.07 PUMP SUCTION DIFFUSERS**

- A. Suction diffusers shall be installed on suction side of each end suction pump instead of minimum 5 pipe diameters straight pipe and strainer.

### 3.08 VACUUM BREAKERS

- A. Install vacuum breakers as needed for proper condensate drainage at steam using apparatus.

### 3.09 ORIFICE PLATE FLOW METERS

- A. Install flow meters as indicated on Drawings and as detailed.
- B. Flow meters and eccentric plug valves shall be used in lieu of calibrated balance valves 2-1/2" and larger.

### 3.10 AIR VENTS

- A. Install manual air vents where indicated on Drawings, details and at high points where air may collect.

END OF SECTION

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Pipe and equipment supports.
- B. Adequacy check and stiffening of existing steel

## 1.02 EXISTING STRUCTURE DRAWINGS

- A. Drawings of existing structure are available if needed. Conduct necessary field measurements to determine or confirm structure dimensions, steel member locations and sizes, as applicable.

## 1.03 SUBMITTALS

- A. Shop Drawings:
  - 1. Piping plans and elevations showing Contractor-designed pipe support systems including pipe supports mark numbers, types, locations, actual loads and movements. Submittal only required for:
    - a. Mechanical piping
  - 2. Details for semi-engineered supports. Support details shall show localized stiffening of support steel at support connection, where applicable.

## 1.04 QUALITY ASSURANCE

- A. Where pre-engineered standard supports are used:
  - 1. Contractor's professional engineer's seal is not required for design of support.
  - 2. Contractor's professional engineer's seal is required for design of attachment of support to structure where details are not included as part of the standard support (e.g., weld requirements, bolts, anchor rods, expansion anchors, etc.)
  - 3. Standard supports (including all components) shall be certified by manufacturer as acceptable for intended use on this project; see article "Pipe Support Design".
- B. Supplementary steel and stiffening of existing steel shall be designed by or under direction of professional engineer registered in State of Utah and retained by Contractor. Submittals shall be signed and sealed by such engineer.

**PART 2 PRODUCTS**

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Anvil International (Grinnell).
- B. Cooper B-Line.
- C. Unistrut.
- D. NPS Industries.
- E. Piping Technology.

## 2.02 PIPE SUPPORT SYSTEM DESIGN

- A. Design pipe support systems for following pipe systems:
  - 1. Hot Water Heating Pipes.
  - 2. Chilled Water Cooling Pipes.
- B. Pipe support selection and application: using pipe support spacing shown in pipe support spacing table below with following additional requirements:
  - 1. Additional supports are required at concentrated loads between supports such as flanges, valves, specialties, etc.
  - 2. Support spacing values in following table shall be reduced by 25% when pipe changes direction between supports.

Nominal Pipe or Tube Size	Water Service		Vapor Service	
	ft	m	ft	m
1/4	7	2.1	8	2.4
3/8	7	2.1	8	2.4
1/2	7	2.1	8	2.4
3/4	7	2.1	9	2.7
1	7	2.1	9	2.7
1-1/4	7	2.1	9	2.7
1-1/2	9	2.7	12	3.7
2	10	3.0	13	4.0

- C. Locate supports for pipe connected to equipment to limit equipment reactions to allowable reactions specified by equipment manufacturer.
- D. Supports for pipe that terminate with Owner pipe connection shall accommodate thermal movement and loads imposed by Owner's pipe.

2.03 PIPE SUPPORT DESIGN

- A. Design all supports unless support components are sized on Drawings.
- B. Where pre-engineered standard supports are used, Contractor's design requirements include:
  - 1. Obtaining manufacturer's certification that manufacturer's support design conforms to above referenced standards.
  - 2. Verification that manufacturer's specified allowable support loads exceed actual loads for particular support application(s).
  - 3. Where applicable, verification that pipe movement at support does not exceed manufacturers allowable.
- C. Include type, size and length of welds and type and size, type and number of bolts required for attachment of pipe support to support steel.
- D. Design to accommodate hydrostatic testing of pipe.
- E. Where pipe routing is shown on Drawings, conduct necessary field measurements as required to verify clearance and constructability of supports prior to support design and fabrication. Costs for redesign of supports or field modifications of new construction due to lack of field measurements shall be borne by Contractor.
- F. Supports that induce torsion in support member not permitted.
- G. Semi-engineered supports.

**2.04 EQUIPMENT SUPPORT DESIGN**

- A. Design equipment support system and supports.
- B. Base equipment support design upon following parameters:
  - 1. Support loads.
  - 2. Equipment movements at supports.
  - 3. Equipment manufacturer's requirements.
- C. Equipment support selection and application: MSS SP-69.
- D. Equipment support design: MSS SP-58.
- E. Where equipment supports are designed by entity other than equipment supplier, obtain equipment supplier's approval of support system.

**2.05 PIPE AND EQUIPMENT SUPPORTS**

- A. Materials and manufacture: MSS SP-58.
- B. Supports and accessory items shall have manufacturer's standard shop-applied primer and standard finish coat, unless specified otherwise.
- C. Provide insulation protection shields of sufficient size and gage to prevent crushing of insulation at supports.

**PART 3 EXECUTION**

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Insulating and jacketing, including, but not limited to:
  - 1. Air ducts not supplied with factory- or shop-applied liner.
  - 2. Piping systems indicated on Drawings.
  - 3. Equipment insulation not otherwise insulated by equipment manufacturer.

1.02 INFORMATIONAL SUBMITTALS

- A. Product Data: Schedule for insulating materials, including adhesives, fastening methods, and fitting materials, and intended use. Include catalog sheets indicating density, thermal characteristics, jacket, installation instructions.

1.03 QUALITY ASSURANCE

- A. Products shall conform to NFPA 90A and 90B with special regard to fire hazard classification requirements of NFPA 255, including vapor barriers and adhesives.
- B. Products shall possess a flame spread rating of not over 25 without evidence of continued progressive combustion and a smoke developed rating no higher than 50.
- C. Materials shall be asbestos-free.

1.04 JOB CONDITIONS

- A. Perform Work at ambient and equipment temperatures as recommended by adhesive manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver material to job site in original non-broken factory packaging, labeled with manufacturer's density and thickness.
- B. Protect insulation during storage and in erected state from damage. Remove and replace all damaged insulation and jacketing.

**PART 2 PRODUCTS**

2.01 ADHESIVES AND COATINGS

- A. Compatible to mechanical surfaces, insulations, and jackets to which they are applied in both wet and dry state.
- B. Fire-retardant, moisture-resistant, mildew-resistant and verminproof.
- C. Suitable for temperature of systems to which they are applied.
- D. Wire mesh reinforcing: 22-gage, 1" galvanized.
- E. Glass fabric reinforcing: Childers Chilglass No. 1, or equal.
- F. Insulation bonding adhesive to metal surfaces: Foster Products Corp. No. 85-20, or equal.
- G. Insulating and finishing cement: P. K. Manufacturing "Quick Cote," Ryder "V-Cement," or equal.

- H. Coating and vapor barrier treatment: Foster Products Corp. No. 30-35, or equal.
- I. Elastomeric insulation to metal surfaces bonding adhesive: Armstrong 520, Rubatex R-373, or equal.
- J. Lap adhesives: Foster Products Corp. No. 85-20, or equal.
- K. Lagging adhesives: Foster Products Corp. No. 30-36, or equal.
- L. PVC jacket lap and seam adhesive: "Zeston" Perma-weld adhesive by Manville.

## 2.02 JACKETS

- A. Puncture resistance rating based on ASTM D781 test method.
- B. Permeance ratings based on ASTM E96, Procedure A.
- C. Type P-1 jacket:
  - 1. Material: Heavy-duty, fire-retardant, glass fiber reinforced material with self-sealing lap.
  - 2. Factory applied to insulation.
  - 3. Finish: White vinyl or white kraft suitable for painting.
  - 4. Bench puncture resistance: 50 units minimum.
  - 5. Permeance: 0.02 perms, maximum.
  - 6. Vapor barrier: 0.001" aluminum foil adhered to inner surface of jacket.
  - 7. Manufacturer: Owens-Corning Type ASJ, or equal.
- D. Type D-1 jacket:
  - 1. Material: Heavy-duty, fire-retardant, glass fiber reinforced material.
  - 2. Factory applied to insulation.
  - 3. Finish: White vinyl or white kraft suitable for painting.
  - 4. Bench puncture resistance: 25 units minimum.
  - 5. Permeance: 0.02 perms, maximum.
  - 6. Vapor barrier: 0.001" aluminum foil adhered to inner surface of jacket.
  - 7. Manufacturer: Owens-Corning Type ASJ, or equal.
- E. Type D-2 jacket:
  - 1. Material: Glass fiber reinforced.
  - 2. Factory applied to insulation.
  - 3. Finish: White kraft.
  - 4. Bench puncture resistance: 15 units, minimum.
  - 5. Permeance: 0.01 perms, maximum.
  - 6. Vapor barrier: Aluminum laminated to inner surface of jacket.
  - 7. Manufacturer: Owens-Corning Type FRK, or equal.
- F. Type E-1 jacket:
  - 1. Material: 20 x 20 mesh glass fabric.
  - 2. Embed in coat of lagging adhesive, finish with second coat of lagging adhesive.
  - 3. Manufacturer: Power Marketing "Duramesh" Type 205, or equal.
- G. Type D-3 jacket:
  - 1. Material: 0.016" thick 303 or 302 aluminum.
  - 2. Jacket cut to size with 2" overlap. Banded 12" oc; seam calked with aluminum color silicon sealant.
  - 3. Manufacturer: Pabsco Metals Corp., or equal.
- H. Banding:
  - 1. Over aluminum jacketing with insulation less than 13" diameter: Stainless steel, 1/2" x 0.020"; A. J. Gerrard & Co., No. 305-SS with No. 202-SS seals.

2. Over aluminum jacketing with insulation larger than 13", but less than 6'-0" in diameter: Stainless steel, 3/4" x 0.020"; A. J. Gerrard & Co., No. 311-SS with No. 204-SS seals.
3. Over aluminum jacketing with insulation larger than 6'-0" diameter: Stainless steel, 3/4" x 0.022" Expand-R-Strap"; A. J. Gerrard & Co.
4. Maximum spacing 12" oc.

## 2.03 INSULATION

- A. Insulating materials: Fire-retardant, moisture- and mildew-resistant, and verminproof. Insulation shall be suitable to receive jackets, adhesives, and coatings as indicated.
- B. Glass fiber insulation: Inert inorganic material, noncorrosive to mechanical surfaces, preformed into flexible or rigid board as indicated, suitable for temperatures to 450°F.
- C. Insulating cement: P. K. "Super Stick" or Ryder "G.P.," dry density 34 lb/cu ft, thermal conductivity 0.91 Btu-in/hr-sq ft-°F at 400°F, or other asbestos-free equal suitable for same temperature range as adjacent pipe or insulation.
- D. Filling and finishing cement: P. K. "Quick Cote" or Ryder "MW," dry density 40 lb/cu ft, thermal conductivity 0.89 Btu-in/hr-sq ft-°F at 400°F.
- E. Type BS-1 flexible fiberglass insulation:
  1. Density: 3/4 lb/cu ft.
  2. Conductivity: Not more than 0.31 Btu-in/hr-sq ft-°F at 75°F.
  3. Manufacturer: Owens-Corning Fiberglas Type 75P "Ductwrap," or equal.
- F. Type BS-2 rigid fiberglass insulation:
  1. Temperature rating: -20 to 850°F only for pipe insulation.
  2. Density: 3 lb/cu ft.
  3. Conductivity: Not more than 0.22 Btu-in/hr-sq ft-°F at 75°F.
  4. Manufacturer: Owens-Corning Fiberglas 25, or equal.
- G. Type BS-3 calcium silicate pipe or block insulation:
  1. ASTM C533, Type 1
  2. Temperature rating: 1,200°F (650°C).
  3. Density: 14.5 lb/cu ft (232 kg/cu meter).
  4. Conductivity: Not more than 0.50 Btu-in/hr-sq ft-°F (0.07 W/m-K) at 400°F (200°C).
  5. Manufacturer: Johns-Manville Thermo-12 Gold, or equal.
- H. Type BS-4 elastomeric thermal insulation:
  1. Temperature rating: -40 to 220°F.
  2. Density: 5.5 lb/cu ft.
  3. Conductivity: Not more than 0.27 Btu-in/hr-sq ft-°F at 75°F.
  4. Permeance: 0.19 perms per inch.
  5. Manufacturer: Armstrong "AP Armaflex," or equal.
- I. Type BS-5 rigid phenolic foam insulation:
  1. Temperature rating: -40 to 275°F.
  2. Density: 2 lb/cu ft.
  3. Conductivity: Not more than 0.23 Btu-in/hr-sq ft-°F at 75°F.
- J. Type BS-6 expanded urethane insulation:
  1. Temperature rating: -100°F to 220°F.
  2. Conductivity: Not more than 0.16 Btu-in/hr-sq ft-°F at 75°F.

## PART 3 EXECUTION

### 3.01 PREPARATION

- A. Do not install covering before piping and equipment has been tested.
- B. Verify surface is clean and dry prior to installation. Verify insulation is dry before and during application. Finish with systems at operating conditions.

### 3.02 INSTALLATION - GENERAL

- A. Verify insulation is continuous through *\*inside\** walls. *\*Pack around pipes and fireproof self-supporting insulation material, fully seal.\**
- B. Insulate fittings, *\*in-line specialties,\** and valves. Do not insulate unions, flanges necessary for maintenance of equipment, strainers, flexible connections, and expansion joints. Terminate insulation neatly with plastic material troweled on bevel.
- C. Finish insulation neatly at hangers, supports, and other protrusions.
- D. Locate insulation or cover seams in least visible locations.
- E. Insulating materials shall be installed with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection or frequent service or repair is required, and to allow for expansion.
- F. Following systems shall be insulated for complete vapor barrier protection:
  - 1. Cold potable water piping.
  - 2. Refrigerant suction piping.
  - 3. Externally insulated ductwork.
  - 4. Chilled water piping, valves, and accessories.
  - 5. Chiller evaporator.
  - 6. Roof drain piping.

### 3.03 INSTALLATION - GLASS COVERING

- A. Fit glass without unnecessary wrinkles or seams.
- B. Size glass immediately upon application with lagging adhesive.
- C. Apply adhesive at no less than 1 gal/80 sq ft of surface.
- D. Overlap seams not less than 2" .

### 3.04 INSTALLATION - PIPING, VALVE, AND FITTING INSULATION

- A. Apply insulation to piping with bonding adhesive, with butt joints and longitudinal seams closed tightly.
- B. Laps on factory-applied jackets shall be 1-1/2" minimum width firmly cemented with lap adhesive, or be pressure sealing type lap.
- C. Cover joints with factory furnished tape (2" minimum width) to match jacket, firmly cemented with lap adhesive.
- D. Install factory-molded insulation for fittings as indicated for valve insulation.
- E. For finishing of insulated pipe fittings, one piece PVC fitting covers may be used.
- F. Taper terminations of pipe insulation ends.

- G. Where thermal pipe shields are used at hanger locations, insulation shall extend to thermal shield. Where vapor barrier is required, Contractor shall be responsible for continuity of vapor barrier at thermal shield.
- H. Where thermal pipe shields are not used at hangers for piping with vapor barrier, insulation shall be Type BS-3 to eliminate compression. Type BS-3 insulation shall extend for twice length of metal shield.
- I. Insulation at anchors, secured directly to pipe surface, shall extend up anchor for distance of 4 times insulation thickness. Assure vapor seal at termination of vapor barrier.
- J. Refrigeration piping application for Type BS-4:
  - 1. Slip insulation on pipe prior to connection wherever possible, and seal butt joints with adhesive manufactured by Armstrong No. 520, or equal.
  - 2. Where slip-on technique is not possible, slit and apply insulation to pipe, and seams and butt joints sealed with 520 adhesive in neat manner.
- K. Piping and fittings not to be insulated: Fire protection piping and fittings, sanitary waste, compressed air, natural gas, gasoline, fuel oil, vent, emergency generator radiator piping.

### 3.05 EQUIPMENT INSULATION INSTALLATION

- A. Provide insulation clips where necessary. Field welding shall be performed by certified welders. No welding shall be performed on lined tanks and vessels.
- B. Leave code stamps uncovered. Provide nonferrous replica of nameplates, code stamps, etc., that will be covered by insulation. Field pack behind extended nameplates.
- C. Reinforce insulation at corners and openings with metal beading.
- D. Inspection ports, manholes, and access covers:
  - 1. Construct insulation to allow removal of covers without disturbing shell insulation.
  - 2. Access cover insulation shall be attached to sectional sheet metal covers, to allow removal for access to access cover retaining bolts, and replacement without damage.
  - 3. Insulate hinges or any other protrusions extending beyond insulation surface.
  - 4. Access cover insulation construction subject to review of Engineer.

### 3.06 INSTALLATION - VENTILATION DUCTWORK AND EQUIPMENT

- A. Apply duct insulation evenly over duct surface, secured with bonding adhesive applied in transverse strips, 12" oc. Insulation for ductwork over 24" wide and underside and sides of ducts with rigid insulation shall be additionally secured with weld pin or stick clip fasteners not over 18" oc. Where weld pin fasteners are used, they shall be installed without damage to interior galvanized surface. Neatly clip pins back to each fastener.
- B. Where vapor barrier jackets are specified, pins shall be jacketed over with matching materials or grouted caps, and sealed vaportight.
- C. Cut and miter insulation without factory jacket to suit surface. Voids, seams, and joints shall be built up with insulating cement, finished to smooth surface, and covered with glass fabric applied as specified.
- D. For surfaces requiring vapor barrier jackets, apply two coats of vapor barrier mastic, after application of insulating cement. Embed layer of glass fiber reinforcing fabric between coats and finish with glass fabric applied as specified.
- E. Where Type D-I jackets are used, all joints and seams shall be firmly butted together and covered with 6" wide glass cloth set in mastic. After first coat is dry, apply second coat of mastic.

- F. Where Type D-2 jackets are used, all joints and seams shall be firmly butted together and covered with factory furnished tape, 3" minimum width. Tape shall match jacket and shall be of same manufacturer as insulation and jacket.
- G. Ductwork not to be insulated:
  - 1. Ductwork internally lined. Refer to Section 23 31 00.
  - 2. Exhaust system ductwork.

3.07 INSULATION THICKNESS SCHEDULE

- A. Furnish and install insulation and jackets on piping, valves, and piping accessories where required. Thickness shall be in accordance with Mechanical Standard M-1008, or as noted below.
- B. Piping insulation application schedule:

Service	Insulation	Jacket	Thickness
Heating Water Piping (125°F)	BS-2	P-1	1"
Chilled Water Piping (45°F)	BS-2	P-1	1"

3.08 DUCT AND EQUIPMENT INSULATION SCHEDULE

Item	Insulation Type	Jacket Type	Insulation Thickness
Outside Air Ductwork Exposed	BS-2	D-1	2"
Outside Air Ductwork Concealed	BS-2	D-2	1"
Mixed Air Ductwork and Plenum	BS-2	D-1	1"
Exposed Supply Ducts in Equipment Room	BS-2	D-1	1"
Concealed Supply Ducts	BS-1	D-2	1"

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Procedures, general.
- B. Final reports.
- C. Contractor responsibilities.
- D. Preparation.
- E. Schedule of systems requiring testing, adjusting, and balancing services.

1.02 SYSTEM REQUIREMENTS

- A. Prepare each system for testing and balancing.
- B. Cooperate with testing organization, provide access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting, and balancing.
- C. Notify testing organization 7 days prior to time system will be ready for testing, adjusting, and balancing.
- D. Perform specified services with Contractor's qualified personnel, or employ and pay for qualified organization to perform specified services.
- E. Perform testing of control station equipment, balancing of distribution system, and adjustment of terminal devices for HVAC systems of Project.
- F. Provide instruments required for testing, adjusting, and balancing operations.
  - 1. Make instruments available to Engineer to facilitate spot checks during testing.
  - 2. Retain possession of instruments; remove from Site at completion of services.
- G. Furnish material, tools, and labor required to perform start-up of each respective item of equipment, instrument and system.
- H. Provide information and assistance required, cooperate with test, adjust, and balance services.
- I. Comply strictly with specified manufacturer's or Engineer's procedures in starting up specified systems.

1.03 SUBMITTALS

- A. Prior to start of Work, submit name of organization and Contractor personnel proposed to perform services. Designate managerial responsibilities for coordination of entire testing, adjusting, and balancing.
- B. Submit documentation to confirm organization and personnel qualifications.
- C. Submit 3 preliminary specimen copies of each of report forms proposed for use.
- D. Fifteen days prior to Substantial Completion, submit 3 copies of final reports, or 1 electronic copy. Submit reports of testing, adjusting, and balancing which is postponed due to seasonal, climatic, occupancy, or other reasons beyond Contractor's control, promptly after execution of those services.
- E. Schedule of start-up to Engineer.

- F. Contractor shall prepare instrument calibration reports in duplicate for each instrument and control loop. Include instrument calibration data and status of equipment. Note any deficiencies yet to be corrected on instruments that are suitable for operation (e.g.: broken lenses, faulty local indicators on transmitters that can still perform correct output transmission) Contractor shall correct these deficiencies at earliest possible date. Copies shall be submitted for Resident Project Representative's review. Each calibration report shall be signed by Contractor's representative witnessing test.
1. Electrical systems test reports: Typewritten, listing equipment used, person or persons performing tests, date tested, circuits tested, and results of tests.
  2. Environmental test reports:
    - a. Preliminary:
      - 1) Submit 3 copies of documentation to confirm compliance with quality assurance provisions:
        - a) Organization supervisor and personnel training and qualifications.
        - b) Specimen copy of each report form proposed for use.
      - 2) Second: At least 15 days prior to starting field work, submit 3 copies of:
        - a) Set of report forms filled out as to design flow values and installed equipment pressure drops, and required cfm for air terminals.
        - b) Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each. Show:
          - (1) Discrepancies noted between data shown and Contract Documents.
          - (2) Additional, or more accurate, instruments required.
          - (3) Requests for re-calibration of specific instruments.
      - 3) Third: At least 15 days prior to Contractor's request for final inspection, submit three copies of final reports, on applicable reporting forms, for review.
        - a) Schedule testing and balancing of parts of systems which is delayed due to seasonal, climatic, occupancy, or other conditions beyond control of Contractor, as early as proper conditions will allow, after consultation with Engineer.
        - b) Submit report of delayed testing promptly after execution of those services.
    - b. Form of final reports:
      - 1) Each individual final reporting form must bear signature of person who recorded data and that of testing, adjusting, and balancing supervisor of reporting organization.
      - 2) When more than 1 certified organization performs testing, adjusting, and balancing services, firm having managerial responsibility shall make submittals.
      - 3) Identify instruments of types that were used, and last date of calibration of each.
      - 4) Record and submit all data measured including air flow, liquid flows, pressure drops, motor loads, and all other data requested in "Environmental Systems," this Section.
- G. At completion of Work, Contractor shall submit to Owner certification that equipment has been commissioned and is in operating condition in accordance with Contract Documents.
- H. Final reports:
1. Organization having managerial responsibility shall make reports.
  2. Each form: Bear signature of recorder, and that of supervisor of reporting organization.
  3. Identify each instrument used and latest date of calibration of each.

#### 1.04 QUALITY ASSURANCE

- A. Comply with procedural standards of certifying association under whose standards service will be performed.
- B. Notify Engineer 3 days prior to beginning of operations.
- C. Accurately record data for each step.
- D. Comply with applicable procedures and standards of certification sponsoring association; either:
  1. "National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronics Systems," by AABC, or "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems," by NEBB.

2. Perform services under direction of supervisor who is designated and qualified under certification requirements of sponsoring association.
  3. Calibration and maintenance of instruments shall be in accordance with requirements of standards, and calibration histories for each instrument shall be available for examination.
  4. Accuracy of measurements shall comply with requirements of standards.
- E. Comply fully with procedural standards of certifying association under whose standards service will be performed.
1. Execute each step of prescribed testing, adjusting, and balancing procedures without omission.
  2. Accurately record required data.

#### 1.05 JOB CONDITIONS

- A. Prior to start of testing, adjusting, and balancing, verify that required "job conditions" are met:
1. Systems installation is complete and in full operation.
  2. Outside conditions are within reasonable range relative to design conditions.
  3. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.
- B. Verify that requirements for preparation for testing and balancing have been met for elements of each of systems that require testing.

#### 1.06 COORDINATION

- A. Coordinate services with Work of various trades to ensure rapid completion of services.
- B. Promptly report to Engineer any deficiencies noted during performance of services.

### **PART 2 PRODUCTS**

#### 2.01 MATERIALS

- A. Provide and maintain tools and test equipment in first-class condition and quantities sufficient to assure successful performance and completion of required Work.
- B. Furnish and use materials in accordance with these Specifications. Materials shall be of first-class quality, free from defects or imperfections, of recent manufacture, unused and of classification and grade specified.
- C. Test equipment shall have recent calibration checks by equipment manufacturer or authorized facility to assure accuracy of commissioning process.
- D. Piping system joint leak testing compound: "Leak-Tek," or equal.
- E. Anti-rust compound for packing gland threads and valve stems: "Moly-Cote" or "Fel-Pro."

### **PART 3 EXECUTION**

#### 3.01 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing. Retain possession of instruments and remove at completion of services.
- B. Verify installation of system to be tested is complete and in continuous operation.
- C. Verify ambient conditions and related facilities are in full operation.

### 3.02 MECHANICAL SYSTEMS

- A. Bearings:
  - 1. Inspect for cleanliness; clean and remove foreign materials.
  - 2. Verify alignment.
  - 3. Replace defective bearings, and those that run roughly or noisily.
  - 4. Grease as necessary, and in accordance with manufacturer's recommendations.
- B. Drives:
  - 1. Adjust tension in V-belt drives, and adjust varipitch sheaves and drives for proper equipment speed.
  - 2. Adjust drives for alignment of sheaves and V-belts.
  - 3. Clean; remove foreign materials before starting operation.
- C. Motors:
  - 1. Check each motor for amperage comparison to nameplate value.
  - 2. Correct conditions which produce excessive current flow, and which exist due to equipment malfunction.

### 3.03 ENVIRONMENTAL SYSTEMS

- A. Perform testing of central station equipment, balancing of distribution systems, and adjusting of terminal devices for:
  - 1. Air handling units.
  - 2. Supply and exhaust fans.
  - 3. Air distribution systems.
  - 4. Volume Control Units (VCU): Minimum and maximum airflow.
- B. Air balancing:
  - 1. Make measurements in accordance with recognized procedures and practices of certifying association.
  - 2. Measure air volume discharged at each outlet and adjust air outlets to design air volumes within 10% over or under. For variable air volume system, measure air volume discharge at each outlet and adjust both maximum and minimum cfm within 10% over or under design settings.
  - 3. Adjust fan speeds and motor drives within drive limitations for required air volume. Set speed to provide air volume at farthest distance without excess static pressure.
  - 4. Measure and adjust air supply and exhaust fan units to deliver design conditions at 100%.
  - 5. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
  - 6. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan.
  - 7. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
  - 8. Evaluate space and zone temperature conditions to determine adequate performance of systems to maintain temperatures without draft.
  - 9. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
  - 10. Mark balancing dampers and cocks.

### 3.04 INSTRUMENTATION SYSTEMS

- A. Commission controls and instruments prior to start-up to assure in situ performance in accordance with specifications under simulated operating conditions. Contractor to determine initial start-up conditions.
- B. Remove shipping stops from instruments before starting with procedures listed herein. Contractor shall have instruction manuals available, and shall install miscellaneous components such as charts, illumination, mercury, etc., which have been supplied separately but are integral parts of equipment.

- C. If any doubt exists as to correct method for calibrating or checking calibration of instrument, manufacturer's printed recommendations shall be used.
- D. Many instruments contain small supply pressure gages or output pressure gages. Calibration of these gages will not be required. However, if gage is found to be defective, instrument involved shall be immediately called to attention of Engineer and reporting of its condition confirmed in writing.
- E. If any instrument cannot be properly adjusted, it shall be immediately called to attention of Engineer and report of its condition confirmed in writing.
- F. Instrument check: Verify data on nameplate with respect to conditions of range, operating temperature, specific gravity, and components as stated on unit specifications. Any discrepancies shall be immediately called to attention of Engineer and report of condition confirmed in writing.
- G. Test procedures for new equipment and controls:
  - 1. Check handswitches, pushbuttons, and pilot lights.
  - 2. Check interlocking circuits installed for conformance to schematic diagrams and "Sequence of Operation."
  - 3. Perform Work of placing in initial operation equipment installed or wired under this contract, following instructions and recommendations of equipment manufacturers.
    - a. After energizing and prior to start-up, check control circuits and programs for proper sequence of operation and interlocking functions.
    - b. Wiring changes required as result of such checks shall be properly identified by changing terminal strip and/or wiring markers.
  - 4. Contractor shall provide necessary construction labor to make equipment final adjustments that are required to place systems in good operating condition, and furnish labor to assist in solving instrument or control problems.
  - 5. Contractor shall calibrate instruments and components in accordance with manufacturer's calibration data over full operational range, prove instruments to be within published specification, accuracy, and affix calibration sticker. Instruments shall be calibrated individually and where applicable, as system (i.e., control loop transmitter, controller, and valve). Components which have adjustable features shall be carefully set for specific conditions and applications of this Project. Each calibration sticker shall be signed by Contractor's representative witnessing test.
  - 6. Calibration sticker shall contain the following information: Equipment identification tag number, range of calibration, and date and name of person doing calibration.
  - 7. Pressure gages: Shall be checked at 10%, 50%, and 90% of their ranges for linearity within Manufacturer's stated specifications.
  - 8. Gages not meeting manufacturer's specifications shall be repaired or replaced.
  - 9. Dial thermometers shall be checked at mid-range and ambient temperature. Thermometers not meeting manufacturer's specifications shall be repaired or replaced.
  - 10. Temperature switches: Calibrate in accordance with manufacturer's specifications.
  - 11. Panel-mounted instruments:
    - a. Receiver instruments: Check zero and span at 10%, 50% and 90% of range by impressing measured signal into input or signal connections or instrument.
    - b. Controllers:
      - 1) Controllers shall be checked for proper operation and adjusted in accordance with manufacturer's instructions. Vary process input signal and check output signal for direction.
      - 2) Set initial proportional band, reset rate, and rate time as recommended by Manufacturer. It may be necessary to determine process dynamics in actual operation before settings can be made.
      - 3) Control loops shall be observed for operability and conformance to specifications by impressing simulated input signal at primary element and checking response of final control element.
    - c. Integrators, ratio relays, etc.: Check in conformance to manufacturer's recommendations. Receiver integrators can be calibrated for proper operation and multiplication factor by feeding maximum input signal 20 mA for specified period of time with stop watch. Check in

conformance with manufacturer's recommendations. Ratio signals can be simulated to check proper ratio settings and output.

12. Controllers; field mounted: Simulate "Set Point" and "Measured Variable" signals at controller, with separate regulated signals. Check operation as in Item "11., b." preceding.
13. Acceptable calibration standards:
  - a. Vacuum or draft:
    - 1) 0" to 5" w.c.: Inclined water filled manometer graduated in tenths and inches of water.
    - 2) 5" to 25" Hg: Mercury manometer graduated in inches of mercury.
    - 3) 5" to 60" H<sub>2</sub>O: Water manometer graduated in inches of water.
  - b. Pressure:
    - 1) 0" to 5" w.c.: Inclined water filled manometer graduated in tenths and inches of water.
    - 2) 5" to 60" w.c.: Water manometer graduated in inches of water.
    - 3) 3 to 25 psig: Mercury manometer graduated in psi.
    - 4) 25 to 150 psig: Precision pressure gage, 0-160 psi, 1/4 of 1% accuracy, 8-1/2" dial minimum.
    - 5) 150 to 750 psig: Precision pressure gage, 0-800 psi, 1/2 of 1% accuracy, 8-1/2" dial minimum.
    - 6) 750 to 2,750 psig: Precision pressure gage, 0-3,000 psi, 1/2 of 1% accuracy, 8-1/2" dial minimum.
  - c. Differential:
    - 1) 0" to 5" w.c.: Inclined water filled manometer graduated in tenths and inches of water.
    - 2) 5" to 300" w.c.: Mercury manometer graduated in inches of water.
    - 3) 5 to 25 psig: Mercury manometer graduated in psi.
    - 4) Above 25 psig: Use pressure gages listed hereinbefore.
  - d. Temperatures:
    - 1) -20 to 250°F: Laboratory thermometers of suitable range.
    - 2) Other ranges: Use thermocouple and precision potentiometer.
  - e. Others:
    - 1) Precision millivolt potentiometer: Portable.
    - 2) Rotameter: Range, 6.5 to 65 cu cm/min of air.
    - 3) Equipment as specified by manufacturer's instructions.
    - 4) Wallace & Tiernan or Mansfield-Green pneumatic calibrator; range, vacuum to +24 psi: For vacuum, pressure, or differential.

### 3.05 SCHEDULE OF SYSTEMS REQUIRING TESTING, ADJUSTING, AND BALANCING SERVICES

- A. Section 23 74 00 - Custom Outdoor HVAC Equipment: AH-1 & 2.
- B. VAV distribution and return air duct system which serves the classroom & trades areas.
  1. VAV boxes and reheat coils.
  2. Supply air diffusers.
  3. Return air main inlets.
  4. Outside air volume.
- C. Duct distribution, registers, and return, and outside air serving Print Shop.
- D. Chilled Water pump, AH coils, Fan coils, and control valves.
- E. Hot Water pump, AH coils, fan coils, reheat coils, and control valves.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. HVAC instrumentation for use with control system specified in Section 23 09 23.

1.02 RELATED REQUIREMENTS

- A. Section 20 05 26 - Piping Specialties For Facilities Services Systems.
- B. Section 23 30 13 - Ducts.
- C. Section 23 09 23 - Direct Digital Controls For HVAC.

1.03 INFORMATIONAL SUBMITTALS

- A. Specification Data Sheets for control components.
- B. Complete instruction manual covering function and operation of control components.
- C. Bill of Materials.

1.04 QUALITY ASSURANCE

- A. Manufacturer shall guarantee control device installed under this Specification to be free from defects in workmanship and material under normal use for a period of one year from date of acceptance of building by Owner.
- B. Replace defective material or workmanship within guarantee period, immediately, without cost to Owner.
- C. Control devices shall be by same manufacturer insofar as practicable. Control devices shall be provided by control system manufacturer unless noted otherwise.

**PART 2 PRODUCTS**

2.01 THERMOSTATS AND TEMPERATURE SENSORS

- A. Electronic immersion and duct temperature sensor:
  - 1. Length: Minimum 8'. Provide 1' of sensor for each sq. ft. of duct cross section.
  - 2. Element: Nickel averaging type.
  - 3. Accuracy:  $\pm 1^{\circ}\text{F}$ .
  - 4. Provide mounting plate, enclosure with cover, conduit connector and wire nuts.
  - 5. Manufacturer: TAC, Barber-Colman, or equal.
- B. Electronic space, single-temperature thermostat:
  - 1. Element: Single, bimetal.
  - 2. Direct or reverse acting, as required for application.
  - 3. Fully proportional with adjustable throttling range and sensitivity.
  - 4. Satin chrome metal, locking type cover with concealed set point and visible thermometer. Suitable for institutional use.
  - 5. Manufacturer: TAC, Barber-Colman, or equal.
- C. Freeze thermostat:
  - 1. 2-position, electric-type, normally closed.
  - 2. Manual reset.

3. 20' sensing element shall cause circuit to open when any 1' section falls below temperature set point.
4. Provide minimum of one 20' element for every 15 sq. ft. of coil face area.
5. Manufacturer: Barber Coleman, Johnson Controls, Inc., or equal.

D. Electronic space temperature sensor with set point adjustment:

1. Single- or dual-scaled set point adjustment as required for application.
2. Sensor: Nickel or platinum 1000-ohm resistance type.
3. Accuracy:  $\pm 1^{\circ}\text{F}$ .
4. Override button: Integral momentary pushbutton.
5. Locking cover with concealed set point and thermometer, suitable for institutional use.
6. Manufacturer: TAC, Barber-Colman, or equal.

## 2.02 HUMIDISTATS

- A. Type: Electronic, room.
- B. Fully proportional with integral set point and throttling range adjustments.
- C. Set point scale shall be calibrated in percent relative humidity.
- D. Element: Nylon or biwood.
- E. Direct or reverse acting as required for application.
- F. Two air connections; supply and outlet, nonbleed type.
- G. Operating range 10%-95% RH.
- H. Manufacturer: TAC, Barber-Colman, or equal.

## 2.03 HUMIDITY SENSORS

- A. Type: Electronic, duct:
  1. Element: Polymer.
  2. Sensing tube shall have sufficient length to measure average duct humidity.
  3. Temperature compensated.
  4. Operational range: 10% to 100%.
  5. Accuracy:  $\pm 3\%$  RH for 5 to 95% RH and  $\pm 5\%$  for 0 to 5% and 95 to 100% RH.
  6. Manufacturer: TAC, Barber-Colman, or equal.
- B. Type: Electronic, room.
  1. Element: All polymer.
  2. Temperature compensated.
  3. Operational range: 0% to 10% RH.
  4. Accuracy:  $\pm 3\%$  RH for 5 to 95% RH and  $\pm 5\%$  for 0 to 5% and 95 to 100% RH.
  5. Manufacturer: TAC, Barber-Colman, or equal.

## 2.04 SENSORS

- A. Temperature:
  1. Type: 1000-ohm resistance.
  2. Element: Nickel, platinum, or silicon.
  3. Accuracy:  $\pm 1^{\circ}\text{F}$ .
  4. Manufacturer: TAC, Barber-Colman, or equal.
- B. Dew point:

1. Accuracy:  $\pm 1.5^{\circ}\text{F}$ .
2. Dew point range:  $-50^{\circ}\text{F}$  to  $140^{\circ}\text{F}$ .
3. Relative humidity range: 12-100%.
4. Pressure range: 0-125 Psia.
5. Manufacturer: Foxboro 2761, Dewcel, or equal.

C. Provide dew point sensor kit, TAC, Barber-Colman, or equal.

## 2.05 DUCT PRESSURE TRANSMITTER

### A. Electronic:

1. Power: 24 volts dc.
2. Output: 4 to 20 mA.
3. Operational pressure range suitable for application.
4. Temperature limits:  $0^{\circ}\text{F}$  to  $175^{\circ}\text{F}$ .
5. Accuracy:  $\pm 1\%$  full span including nonlinear hysteresis, and non-repeatability.
6. Manufacturer: TAC, Barber-Colman, or equal.

## 2.06 LOW DIFFERENTIAL PRESSURE TRANSMITTER AND GAGE

A. Diameter: 4".

B. Pressure range: 0 to 2" or 0 to 6", as appropriate for installation.

C. Power: 24 volts dc.

D. Output: 4 to 20 mA.

E. Accuracy:  $\pm 2\%$  full span output.

F. Manufacturer: Dwyer Series 605 Magnehelic, or equal.

## 2.07 ROOM PRESSURE MONITOR

### A. Electronic:

1. Operation: Controller shall sense differential pressure between 2 spaces by sensing velocity directly. Unit shall be capable of sensing direction of airflow for positive, negative or bi-directional pressure measurement.
2. Pressure sensor:
  - a. Control range: As required for application.
  - b. Provide 2 velocity sensing elements mounted in line with each other and temperature compensating element. Velocity sensing elements shall be ceramic-coated platinum RTD for corrosion resistance and easy cleaning. Velocity measurement shall use constant temperature thermal anemometry. Pressure transducers not acceptable.
  - c. Capable of measuring pressure down to 0.00015" w. g. Bi-directional to determine proper direction of pressure. Uni-directional sensors not acceptable.
  - d. Assembly: ANSI/UL 1479 listed; 2-hour fire rating.
  - e. Temperature compensated over range of  $55^{\circ}\text{F}$  to  $95^{\circ}\text{F}$ .
  - f. Capable of mounting on either side of wall (i.e. in controlled space or in reference space). Provide dip switch to select which side of wall pressure sensor is mounted.
3. Monitor display panel:
  - a. Case: Molded, manufactured with industrial grade plastic and shall mount to double gang electrical box.
  - b. Measure, and display room pressure. Provide access to menu-driven programming options through keypad. Keypad shall be smooth, spill-proof membrane switch.
  - c. Provide tow indicator lights on front of monitor to indicate following conditions:
    - 1) "Red – Alarm" conditions.

- 2) "Green – Nominal" or safe pressure condition.
  - d. Provide protective cover. Cover shall conceal display but not conceal indicator lights.
  - e. Display: Tow line alphanumeric capable of displaying -0.20000 to +0.20000 with resolution of 5% of reading and shall be updated every 1/2 second.
  - f. Provide low and high alarms for both negative and positive pressure. Each alarm shall have unique setpoint.
  - g. Provide audible alarm to sound when pressure \*monitor\*\*controller\* is in alarm condition. Contact for low-pressure remote alarm monitoring shall be SPST. Contact shall close in low alarm condition.
  - h. Output: 0-10 volts dc or 4-20 mA linear proportional to pressure for connection to central control system.
4. Transformer:
    - a. Primary voltage: 120 volts ac.
    - b. Secondary voltage: 24 volts ac.
    - c. Ratings: 20 VA with 0.5 ampere maximum.
  5. Manufacturer: TSI inc. Model 8630-PM, or equal.

## 2.08 DUCT VELOCITY SENSOR/CONTROLLER

- A. Electronic:
  1. Control range: 0" w.g. to 1.5" w. g.
  2. Output: 0-5 volts dc.
  3. Sensitivity:  $\pm 1\%$  full span, maximum.
  4. Repeatability:  $\pm 0.005\%$  full span, maximum.
  5. Manufacturer: TAC, Barber-Colman, or equal.

## 2.09 CONTROL DAMPERS

- A. Materials of construction: 13-gage galvanized sheet steel frame formed into channels and spot welded.
- B. Bearings: Oil-impregnated sintered bronze.
- C. Seals: Synthetic elastomer seals on blade edge and ends
- D. Temperature limits: -20°F to 200°F.
- E. Leakage: 0.5% at 4" w.g. static pressure and 2000 ft/min velocity.
- F. Action: Opposed or parallel, as indicated on Drawings.
- G. 16-gage galvanized steel blades, not over 8" in width.
- H. Manufacturer: TAC, Barber-Colman, or equal.

## 2.10 DAMPER ACTUATORS

- A. Electronic:
  1. Power: 24 volts ac or volts dc, to suit application.
  2. Size adequate to provide smooth modulating action or 2-position action, as required.
  3. Input: 0 - 10 volts dc or 4-20 mA, as required.
  4. Output feedback.
  5. Enclosure: NEMA 3R.
  6. Spring return: As required.
  7. Manufacturer: TAC, Barber-Colman, or equal.

## 2.11 CONTROL VALVES

- A. Two-way (water service):
  - 1. Equal percentage throttling plugs.
  - 2. Construction:
    - a. 2" and smaller: ASTM B61 bronze body, screwed ends.
    - b. 2-1/2" and larger: ASTM A126 cast iron body, bronze trim.
  - 3. Pressure class: 150 psig.
  - 4. Packless type with bellows seal.
  - 5. Provide positive positioners.
  - 6. Manufacturer:
    - a. 2" and smaller: TAC, Belimo, Barber-Colman, or equal.
    - b. 2-1/2" or larger: TAC, Belimo, Barber-Colman, or equal, as required for application.
- B. Three-way (water service):
  - 1. Equal percentage throttling plugs.
  - 2. Construction:
    - a. 2" and smaller: ASTM B61 bronze body, screwed ends.
    - b. 2-1/2" and larger: ASTM A126 cast iron body, bronze trim.
  - 3. Pressure class: 125 psig.
  - 4. Packless-type with bellows seal.
  - 5. Provide positive positioners where required.
  - 6. Manufacturer:
    - a. 2" and smaller: TAC, Belimo, Barber-Colman, or equal.
    - b. 2-1/2" or larger: TAC, Belimo, Barber-Colman, or equal, as required for application.

## 2.12 CONTROL VALVE ACTUATORS

- A. Low-voltage, electronic:
  - 1. Power: 24 volts ac or volts dc, to suit application.
  - 2. Size: Adequate to provide smooth modulating action or 2-position action, as required.
  - 3. Input: 0 to 10 volts dc or 4 to 20 mA, as required.
  - 4. Output feedback.
  - 5. Spring return: As required.
  - 6. Manufacturer:
    - a. 2" and smaller: TAC, Belimo, Barber-Colman, as required for application, or equal.
    - b. 2-1/2" and larger: TAC, Belimo, Barber-Colman, or equal.

## 2.13 AIR FLOW RATE MEASUREMENT STATIONS

- A. Construction: 16-gage galvanized steel, epoxy-coated in fume exhaust applications. Copper air straighteners, sensor, and manifolds.
- B. Dimensions: Equal to duct dimensions where mounted.
- C. Furnish with pressure to electric transducer for static and total pressure measurement, as indicated on Drawings.

## 2.14 AQUASTATS

- A. Type: Line-voltage.
- B. Single-pole, single-throw switching.
- C. Rating: Adequate for applied load, minimum 10.0 amperes at 120 volts.
- D. Dial range: 100°F to 240°F or 60°F to 130°F, depending on application.
- E. Manufacturer: TAC, Barber-Colman, or equal.

**2.15 GAGES**

- A. Control air pressure gages:
  - 1. Diameter: 2" minimum.
  - 2. Mounting: Stem.
  - 3. Scale: 0 to 30 psig, or 0 to 160 psig, as appropriate for installation.
  
- B. Indication receiver gages:
  - 1. Diameter: 3".
  - 2. Mounting: Panel flush-mounted.
  - 3. Pressure range: 0 to 20 psig.
  - 4. Scale: °F, inches w. g., % RH with ranges appropriate to application.
  
- C. Low differential pressure:
  - 1. Diameter: 4".
  - 2. Mounting: Flush.
  - 3. Pressure range: 0 to 2", 0 to 8" as appropriate for installation.
  - 4. Manufacturer: F. W. Dwyer Manufacturing Company, Series 2000, or equal.

**2.16 THERMOMETERS**

- A. Dial:
  - 1. Diameter: 4-1/2".
  - 2. Mounting: Direct swivel type.
  - 3. Scale: -20 to 110, 0 to 260.
  - 4. Graduations: 2°F.
  - 5. Element: Liquid-filled, copper, bulb or averaging type, suitable for installation.
  
- B. Vertical scale:
  - 1. Column height: 4".
  - 2. Mounting: Direct with adjustable mounting.
  - 3. Scale: 0 to 120°F, 30 to 240°F.
  - 4. Graduations: 2°F.
  - 5. Type:
    - a. Liquid: Immersion-type.
    - b. Air: Insertion-type.

**2.17 CONTROL STEP-DOWN TRANSFORMER**

- A. Primary voltage: 120 volts, 60 Hz, single-phase.
  
- B. Secondary voltage: 24 volts ac.
  
- C. Size: As required to power control devices.
  
- D. Manufacturer: TAC, Barber Coleman, or equal.

**2.18 TRANSDUCERS**

- A. Current:
  - 1. Output: 4-20 mA or 0 to 10 volts dc.
  - 2. Accuracy: ±1%.
  - 3. Select transducer for normal measured amperage to be near 50% of full scale range.
  - 4. Provide transducer for monitoring amperage of motors.

**PART 3 EXECUTION**

### 3.01 GENERAL REQUIREMENTS

- A. Size control apparatus to supply and/or operate and control devices served.
- B. Furnish motor operators and duct velocity sensor controller, to high velocity terminal device manufacturer for factory mounting.
- C. Furnish automatic control valves automatic dampers, immersion wells, flow switches, and other devices to be installed by others.
- D. Provide temperature control wiring. Wiring shall include line voltage and low-voltage wiring. Install wiring by licensed electrician employed by Contractor and shall be installed in accordance with provisions of Division 16.
- E. Pneumatic equipment performing interlocking functions shall be panel-mounted and located within 5'-0" of equipment disconnect or starting device unless otherwise indicated.
- F. Provide numbered terminal strips in control panels for interfacing with others. Furnish others with control drawings indicating points of electrical interface.
- G. Provide compressed air gage within 6" of each damper and valve operator.
- H. Provide pressure differential gage across ends of filter bank. Mount gages in control panel face.

### 3.02 INSTALLATION

- A. Compressed air piping shall be hard drawn seamless, copper tubing, except fire retardant polyethylene tubing shall be used in concealed spaces not used as air duct.
- B. Exposed tubing and tubing within mechanical spaces shall be hard drawn seamless copper.
- C. Exposed tubing and conduit shall run parallel to or at right angles to building structure. Adequately support tubing at uniform intervals.
- D. Use sweat fittings throughout for copper tubing except for final connection to operators or other devices where compression fittings would be more suitable.
- E. Polyethylene tubing shall be coded and installed in accessible tube trays with no concealed splices.
- F. Mount room thermostats and temperature sensors 5'-0" above floor, vertically aligned with light switches.
- G. Horizontally align room humidistats and humidity sensors with thermostats.

### 3.03 TESTING

- A. Tests shall be made from time to time during progress of installation to ensure against leaks.

### 3.04 ADJUSTMENT

- A. After completion of installation, regulate and adjust thermostats, temperature sensors, humidity sensors, humidistats, pressure sensors, controllers, operators, and other equipment provided.

### 3.05 OWNER INSTRUCTION

- A. See Section 23 09 23.

END OF SECTION

## **PART 1 GENERAL**

### 1.01 RELATED DOCUMENTS

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

### 1.02 SUMMARY

- A. This Section includes the Building Management System (BMS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units.
- B. Related Sections include the following found in Division 20000, 23000, and 26000 Sections of the Specifications:
  - 1. Fire Alarm Systems.
  - 2. Basic Mechanical Requirements.
  - 3. Refrigeration Equipment.
  - 4. Air Handling Equipment.
  - 5. Test and Balance.
  - 6. Basic Electrical Requirements.
  - 7. Cables, Low Voltage. (600 Volts and below)
  - 8. Wiring Devices.
  - 9. Motor Control Centers.
  - 10. Basic Electrical Materials.

### 1.03 SYSTEM DESCRIPTION Ethernet (IEEE 802.3), peer-to-peer CSMA/CD

- A. Furnish all labor, materials, equipment, and service necessary for a complete and operating temperature control system, utilizing a high speed peer to peer network of interoperable Direct Digital Controls (DDC), Graphical User Interface (GUI) with color graphic displays available for a minimum of at least p 64 possible client computers, and electronic interfaces and actuation devices, as shown on the drawings and as described herein.
- B. The Local Area Network (LAN) shall be either a 10 or 100 Mbps Ethernet network supporting BACnet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Universal Network Controllers (UNCs), user workstations and a local host computer system.
- C. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.
- D. The system will consist of an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol, as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2004, BACnet functionality to assure interoperability between all system components. Both the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol are required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.
- E. Where utilized by a LonMark/LonWorks based Control System, LonTalk™ packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth.

1. Any such encapsulation of the LonTalk™ protocol into IP datagrams shall conform to existing LonMark™ guide-lines for such encapsulation and shall be based on industry standard protocols.
  2. The products used in constructing the BMS shall be LonMark™ compliant.
  3. In those instances in which Lon-Mark™ devices are not available, the BMS contractor shall provide LonWorks™ devices with application source code, device resource files, and external interface definitions.
- F. The software tools required to network manage both LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2004, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans that are required to meet the functional intent, shall be provided without additional cost to the Owner. Minimum BACnet compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet/Ethernet IP or MS/TP.
- G. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.
1. The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs.
  2. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage.
    - a. This data shall reside on a supplier-installed server for all database access.
    - b. Systems requiring proprietary database and user interface programs shall not be acceptable.
    - c. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network.
    - d. Systems employing a "flat" single tiered architecture shall not be acceptable.
- H. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the authorized office representing the controls manufacturer. The authorized office shall have a minimum of 10 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer when requested. Supervision, calibration and checkout of the system shall be by the employees of the authorized office and shall not be subcontracted. The control contractor shall have an in place support facility within 50 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have emergency service available.
- 1.04 INSTALLATION OF PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION.
- A. Sections from Division 200000 – Common Work Results for Facility Systems Services:
1. Control Valves.
  2. Flow Switches.
  3. Temperature Sensor Wells and Sockets.
- B. Sections from Division 230000 – Ductwork Accessories:
1. Automatic Dampers.

2. Terminal Unit Controls.
3. Outside Air Flow Monitoring Stations.

1.05 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION.

1. Sections from Division 23000 –

1.06 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THIS SECTION.

- A. Sections from Division 26000- Fire Alarm System.
  1. Smoke Detectors (duct).
- B. Section 26000 –Equipment and Motor Wiring.
  1. Variable Frequency Drives (Furnished with Lon Card)
- C. Power Monitoring System Control Units and Intelligent Devices.

1.07 SUBMITTALS.

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
  1. Each control device labeled with setting or adjustable range of control.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
  3. Details of control panel faces, including controls, instruments, and labeling.
  4. Written description of sequence of operation.
  5. Schedule of dampers including size, leakage, and flow characteristics.
  6. Schedule of valves including close-off and flow characteristics.
  7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
  8. Listing of connected data points, including connected control unit and input device.
  9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
  10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- C. External Interface Files: XIF files or object diagrams for each DDC system component (Custom Application Controller and Application Specific Controller) proposed.
- D. Software and Firmware Operational Documentation: Include the following:
  1. Engineering, Installation, Operation and Maintenance manuals.
  2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  3. Device address list.
  4. Printout of software application and graphic screens.
  5. Licenses, guarantee, and warranty documents for all equipment and systems.

- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance instructions and lists of spare parts for each type of control device and compressed air station.
  - 2. Interconnection wiring diagrams with identified and numbered system components and devices.
  - 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
  - 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
  - 5. Calibration records and list of set points.
- G. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- H. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.08 QUALITY ASSURANCE.

- A. **Important:** Bids by wholesalers, distributors, mechanical contractors, ABCS, ACS, and non-franchised contractors shall not be acceptable. The intent of this is to ensure expertise, accountability, single point responsibility and the avoidance of conflict of interests with other divisions and contractors.
- B. The system manufacturer shall, as a minimum, manufacture and supply the Custom Application Controller, Application Specific Controller, Unitary Equipment Controller, Advanced Application Controller, Graphical User Interface, damper actuators, and valve actuator assemblies., except where stated otherwise in this specification.
- C. All work described in this section shall be installed, wired, circuit tested by qualified and certified electricians that are licensed journeymen or enrolled in a qualified electrician apprentice program and properly supervised according to state and local ordinances. Also work described in this section shall be calibrated by factory certified technicians qualified for this work and in the regular employment of the temperature control system manufacturer's local field office.
- D. The Building Management System contractor shall have a full service facility within 50 miles of the project that is staffed with engineers trained in Integrating Interoperable Systems and technicians fully capable of providing LonMark/LonWorks and/or BACnet instructions and routine emergency maintenance service on all system components.
- 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 use.
- F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
- G. Comply with National Electric Code, UL-916 Energy Management Systems, LonMark™, ULC, FCC Part 15, subpart J, Class B Computing Devices.
- H. Comply with EIA Standard 709.1 LonTalk™ protocol for DDC system control components.

1.09 PRE-BID SUBMITTAL.

1.10 DELIVERY, STORAGE AND HANDLING.

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.11 COORDINATION.

- A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment from other divisions including Motor-Control Centers," "Panelboards," and "Fire Alarm" to achieve compatibility with equipment that interfaces with those systems.
- C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- D. Coordinate 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".
- E. Coordinate with the Owner's IT department on locations for Universal Network Controllers, Ethernet communication cabling and TCP/IP addresses.

1.12 WARRANTY AND MAINTENANCE.

- A. All components, system software, and parts furnished and installed by the BMS contractor shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period. Materials furnished but not installed by the BMS contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 standard working hours.

1.13 OWNERSHIP OF PROPRIETARY MATERIAL.

- A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All project developed software and documentation shall become the property of the owner. These include, but are not limited to project graphic images, record drawings, project database, project specific application programming code, and all other associated documentation.

1. PRODUCTS

1.14 APPROVED MANUFACTURERS AND INSTALLING CONTRACTORS

- 1. TAC I/A-Series System as provided and installed by Utah Yamas Controls Inc. Point of contact Bob Hooper 801-990-1950.
- 2. No other contractor or products considered.

## 1.15 DDC EQUIPMENT

- A. The Operator Work Station, Graphical User interface as well as the associated Web services are existing. This contractor shall generate graphics depicting this remodel and all affected mechanical equipment. All new controllers shall be added to the existing communication trunk so that all building ATC functions can be viewed and managed from multiple locations on campus.
- B. Universal Network Controllers (UNC) shall employ a Niagara Framework™ software and hardware architecture solution (solution may be an OEM, licensed or re-branded product implementing the Niagara Framework™) as the foundation for managing and facilitating all services, global and communication functions.
  1. The Universal Network Controllers (UNC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the UNC. It shall be capable of executing application control programs to provide:
    - a. Calendar functions
    - b. Scheduling
    - c. Trending
    - d. Alarm monitoring and routing
    - e. Time synchronization by means of an Atomic Clock Internet site including automatic synchronization
    - f. Integration of LonWorks controller data and BACnet controller data
    - g. Network Management functions for all LonWorks based devices
  2. The Universal Network Controller Type 2 must provide the following hardware features as a minimum:
    - a. One Ethernet Port – 10/100 Mbps
    - b. Two RS-232 ports
    - c. Four RS-RS485 ports electrically isolated
    - d. One LonWorks Interface Port – 78KB FTT-10A with Weidmuller connector
    - e. Power supply 24 VAC or 24 VDC
    - f. Battery Backup
    - g. Real-time clock
    - h. Processor @ 200 MHz or greater
    - i. 64 Mb flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
    - j. 128 Mb Ram or greater
  3. The UNC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the UNC shall be an ODBC compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
  4. The UNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 64 simultaneous users.
  5. Event Alarm Notification and Actions
    - a. The UNC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
    - b. The UNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
    - c. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      - 1) To alarm
      - 2) Return to normal

- 3) To fault
  - d. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
  - e. Provide timed (schedule) routing of alarms by class, object, group, or node.
  - f. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
  - g. Control equipment and network failures shall be treated as alarms and annunciated.
  - h. Alarms shall be annunciated in any of the following manners as defined by the user:
    - 1) Screen message text
    - 2) Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
      - a) Day of week
      - b) Time of day
      - c) Recipient
    - 3) Pagers via paging services that initiate a page on receipt of email message
    - 4) Graphic with flashing alarm object(s)
    - 5) Printed message, routed directly to a dedicated alarm printer
  - i. The following shall be recorded by the UNC for each alarm (at a minimum):
    - 1) Time and date
    - 2) Location (building, floor, zone, office number, etc.)
    - 3) Equipment (air handler #, access way, etc.)
    - 4) Acknowledge time, date, and user who issued acknowledgement.
    - 5) Number of occurrences since last acknowledgement.
  - j. Alarm actions may be initiated by user defined programmable objects created for that purpose.
  - k. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
  - l. A log of all alarms shall be maintained by the UNC and/or a server (if configured in the system) and shall be available for review by the user.
  - m. Provide a "query" feature to allow review of specific alarms by user defined parameters.
  - n. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
  - o. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.
6. Data Collection and Storage
    - a. The UNC shall have the ability to collect data for any property of any object and store this data for future use.
    - b. The data collection shall be performed by log objects, resident in the UNC that shall have, at a minimum, the following configurable properties:
      - 1) Designating the log as interval or deviation.
      - 2) For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
      - 3) For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
      - 4) For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
      - 5) Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
  7. All log data shall be stored in a relational database in the UNC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
  8. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
  9. All log data shall be available to the user in the following data formats:

- a. HTML
  - b. XML
  - c. Plain Text
  - d. Comma or tab separated values
10. Systems that do not provide log data in HTML and XML formats at a minimum shall provide as an alternative Microsoft SQL Server<sup>®</sup>, Oracle 8i or Express<sup>®</sup>, Hyperion Solutions<sup>™</sup> SQL Server.
11. The UNC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other UNC on the network. Provide the ability to configure the following archiving properties, at a minimum:
- a. Archive on time of day
  - b. Archive on user-defined number of data stores in the log (buffer size)
  - c. Archive when log has reached it's user-defined capacity of data stores
  - d. Provide ability to clear logs once archived
12. AUDIT LOG
- a. Provide and maintain an Audit Log that tracks all activities performed on the UNC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it's user-defined buffer size. Provide the ability to archive the log locally (to the UNC), to another UNC on the network, or to a server. For each log entry, provide the following data:
    - 1) Time and date
    - 2) User ID
    - 3) Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.
13. DATABASE BACKUP AND STORAGE
- a. The UNC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
  - b. Copies of the current database and, at the most recently saved database shall be stored in the UNC. The age of the most recently saved database is dependent on the user-defined database save interval.
  - c. The UNC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

C. Control Units General:

Control units, other than for the Workstation Server Software and Hardware as well as for any Universal Network Controllers, shall be based entirely upon the LonMark/LonWorks standards. Provide an adequate number of control units to achieve monitoring and control of all data points specified and necessary to satisfy the sequence of operation for all mechanical systems shown on the plans. Each of the following panel types shall meet the following requirements.

1. Controllers shall be suitable for the anticipated ambient conditions.
  - a. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at -40°F to 140°F and 5 to 95% RH, non condensing.
  - b. Controllers used in conditioned ambient space shall be mounted in dustproof enclosures, and shall be rated for operation at 32°F to 122°F and 5 to 95% RH, non condensing.
2. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Memory: The Control Units shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
4. Diagnostics: The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode and generate an alarm notification.

5. Immunity to power and noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.
6. Automatic staggered restart of field equipment after restoration of power and short cycle protection.

D. Custom Application Control Units:

Modular, comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control applications. CAC's shall be provided for Roof Top Units, Boiler Plant, Chiller Plant and other applications as shown on drawings and shall have published Lon-Works™ application source code, device resource files and external interface definitions.

1. Units monitor or control each input/output point; process information; and at least 50 expressions for customized HVAC control including mathematical equations, Boolean logic, PID control loops with anti-windup, sequencers, timers, interlocks, thermostats, enthalpy calculation, counters, interlocks, ramps, drivers, schedules, calendars, OSS, compare, limit, curve fit, and alarms.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
  - a. Peer to peer primary network level communications supporting at least 200 LonMark™ Standard Network Variables (SNVTs) per CAC utilizing at least 100 different SNVT types as documented by the LonMark™ Interoperability Association to assure present and future compatibility with third party LonMark™ devices. The 200 LonMark™ SNVTs, minimum, must be configurable in any combination – all inputs or all outputs or any combination of input/outputs in any combination of the 100 different, minimum, SNVT types. The XIF SNVT order shall be definable, rather than random, to provide logical and effective LonMark™ network management. With the submittal package, contractor shall provide CAC performance data that specifies the exact maximum number of SNVTs available in any combination and a list of all available SNVT types including the LonMark™ Interoperability Association SNVT number.
  - b. Automatic communications loss detection to maintain normal control functionality regardless of available network communications.
  - c. Discrete/digital, analog, and pulse input/outputs.
  - d. Monitoring, controlling, or addressing data points.
  - e. Local energy management control strategies
  - f. Incorporate internal customizable safeties and limits to prevent third party LonMark™ tools from providing improper and unrealistic inputs to CAC's.
3. Local operator interface port provides for download from and connection to portable workstation.
4. Communication: The Custom Application Controller shall communicate via the Primary Controller Network between BMS Controllers and other LonWorks™ devices. CAC's shall communicate with the Building Controller and ASC's at a baud rate of not less than 78.8 baud using LonWorks™ communications protocol (EIA 709.1).

E. CAC Room Sensor

1. The CAC Sensor shall provide room temperature value to the CAC.
2. The CAC Sensor shall connect directly to the CAC and shall not utilize any of the I/O points of the controller.
3. The CAC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
4. The CAC Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.
5. The CAC Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.

6. The CAC Sensor shall allow for the customization of the color on the esthetic covering as a standard offering.
7. The CAC Sensor shall be supplied in the following manner:
  - a. LCD display for showing (typically) the current temperature.
  - b. Tenant override to allow timed override of unoccupied to occupied mode of operation.
  - c. LED indication of override state.
  - d. Up/Down keys to allow adjustment of the current setpoint
  - e. User interface with the CAC Sensor shall be provided as a configurable function, and shall offer password protection for access to network variable editing.
  - f. ASHRAE 95 compliance (LCD display and sub-base functionality)
  - g. The room sensor shall provide access to additional diagnostic data from a sensor-user keypad request. This Diagnostic mode is displayed on the LCD screens and includes separate displays for the controllers:
    - 1) Subnet and Node Address
    - 2) Errors
    - 3) Alarms
    - 4) Temperature Offset

F. Advanced Application Controller (AAC):

Modular, comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control applications. AAC's shall be provided for large AHU's, Boiler Plant, Chiller Plant and other applications as shown on drawings.

1. Units monitor or control each input/output point; process information; and at least 50 expressions for customized HVAC control including mathematical equations, Boolean logic, PID control loops with anti-windup, sequencers, timers, interlocks, thermostats, enthalpy calculation, counters, interlocks, ramps, drivers, schedules, calendars, OSS, compare, limit, curve fit, and alarms.

G. Application Specific Control Units:

Single board construction comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control and unitary applications. ASCs shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Rooftop Units, and other applications as shown on the drawings. To assure complete interoperability, all ASCs firmware shall support all mandatory and all optional LonMark™ Standard Network Variables (SNVTs) for their LonMark™ profile as documented by the LonMark™ Interoperability Association. Bidder shall provide proof of ASC compliance for all the mandatory and all optional LonMark™ SNVTs. ASCs shall be based on the Echelon Neuron 3150 microprocessor working with the ASCs stand alone control program.

1. Units monitor or control each input/output point; process information; and download from the operator station.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
  - a. Peer to peer primary network level communications with automatic communications loss detection to maintain normal control functionality regardless of available network communications.
  - b. Discrete/digital, analog, and pulse input/output.
  - c. Monitoring, controlling, or addressing data points.
  - d. Appropriate LonMark™ profiles for specific unitary applications.
  - e. Support for all mandatory and optional LonMark™ Standard Network Variable Types (SNVTs) for their LonMark™ profile as documented by the LonMark™ Interoperability Association

- f. Internal customizable safeties and limits to prevent third party LonMark™ tools from providing improper and unrealistic inputs to ASC's.
  3. Local operator interface port located on ASC and ASC sensor provides for download from or upload to portable workstation. All Lon bus devices shall be accessible from either port.
  4. Communication: ASC's shall communicate with the Building Controller and CAC's at a baud rate of not less than 78.8K baud using LonTalk™ communications protocol (EIA 709.1).
  5. ASC units monitor or control each input/output point; process information; and at least 50 expressions for customized HVAC control including mathematical equations, boolean logic, PID control loops with anti-windup, sequencers, timers, interlocks, thermostats, counters, interlocks, compare, limit, and alarms.
  6. All ASC Controller setpoints shall be digital display setpoints with dual setpoint limits (integral hard limits which the user cannot exceed above and below and independent soft limits which are hidden from the user). All digital setpoints shall be network retentive after power outages and after replacement of sensor.
- H. ASC Room Sensor
1. The ASC Sensor shall provide room temperature value to the ASC.
  2. The ASC Sensor shall connect directly to the ASC and shall not utilize any of the I/O points of the controller.
  3. The ASC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
  4. The ASC Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.
  5. The ASC Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.
  6. The ASC Sensor shall allow for the customization of the color on the esthetic covering as a standard offering.
  7. The ASC Sensor shall be supplied in the following manner:
    - a. LCD display for showing (typically) the current temperature.
    - b. Tenant override to allow timed override of unoccupied to occupied mode of operation.
    - c. LED indication of override state.
    - d. Up/Down keys to allow adjustment of the current setpoint
    - e. User interface with the ASC Sensor shall be provided as a configurable function, and shall offer password protection for access to network variable editing.
    - f. ASHRAE 95 compliance (LCD display and sub-base functionality)
    - g. The room sensor shall provide access to additional diagnostic data from a sensor-user keypad request. This Diagnostic mode is displayed on the LCD screens and includes separate displays for the controllers:
      - 1) Subnet and Node Address
      - 2) Errors
      - 3) Alarms
      - 4) Temperature Offset
- I. Unitary Equipment Controller Units:
- Single board construction comprising processor board with programmable, nonvolatile, RAM/EEPROM memory for custom control and unitary applications. ASCs shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Rooftop Units, and other applications as shown on the drawings.
1. The Unitary Equipment Controller shall have the following point count as a minimum.
    - a. 6 Universal Inputs
      - 1) 0-20mA
      - 2) 0-5 VDC
      - 3) Balco Sensors
      - 4) Platinum Sensor

- 5) 10K thermistor
    - b. 4 Analog Outputs
      - 1) 0-20 mA
      - 2) 0-5/10 VDC
      - 3) Individually short circuit protected
    - c. 8 Digital Outputs
      - 1) Triacs
      - 2) LED indication
  2. Units monitor or control each input/output point; process information; and download from the operator station.
  3. The controller shall have removable terminals for:
    - a. 24 VAC Power inputs
    - b. MS/TP Communication terminals
  4. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Peer to peer primary network level communications with automatic communications loss detection to maintain normal control functionality regardless of available network communications.
    - b. Discrete/digital, analog, and pulse input/output.
    - c. Monitoring, controlling, or addressing data points.
  5. Local operator interface port located on UEC and UEC sensor provides for download from or upload to portable workstation. All bus devices shall be accessible from either port.
  6. Communication: UEC's shall communicate with the UNC and ACC at a baud rate selectable of 9.6-76.8 Kbaud utilizing MS/TP.
  7. UEC units monitor or control each input/output point; process information; and at least 50 expressions for customized HVAC control including mathematical equations, Boolean logic, PID control loops with anti-windup, sequencers, timers, interlocks, thermostats, counters, interlocks, compare, limit, and alarms.
  8. All UEC Controller setpoints shall be digital display setpoints with dual setpoint limits (integral hard limits which the user cannot exceed above and below and independent soft limits which are hidden from the user). All digital setpoints shall be network retentive after power outages and after replacement of sensor.
- J. UEC Room Sensor
1. The UEC Sensor shall provide room temperature value to the controller.
  2. Each UEC shall support a minimum of two sensors.
  3. The UEC Sensor shall connect directly to the controller and shall not utilize any of the I/O points of the controller.
  4. The UEC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
  5. The UEC Sensor shall be provided in a modular configuration that allows for the rough in of all wiring without the presence of the electronics or esthetic covering.
  6. The UEC Sensor shall allow for the customization of the color on the esthetic covering as a standard offering.
  7. The UEC Sensor shall be supplied in the following manner:
    - a. LCD display for showing (typically) the current temperature.
    - b. Tenant override to allow timed override of unoccupied to occupied mode of operation.
    - c. LED indication of override state.
    - d. Up/Down keys to allow adjustment of the current setpoint
    - e. User interface with the UEC Sensor shall be provided as a configurable function, and shall offer password protection for access to network variable editing.
    - f. ASHRAE 95 compliance (LCD display and sub-base functionality)

- g. The room sensor shall provide access to additional diagnostic data from a sensor-user keypad request. This Diagnostic mode is displayed on the LCD screens and includes separate displays for the controllers:
  - 1) Subnet and Node Address
  - 2) Errors
  - 3) Alarms
  - 4) Temperature Offset

K. ASC – Fan Coil Unit, Unit Ventilator, Heat Pump, or Packaged Rooftop Controller  
Functionality.

Controls shall be microprocessor based as shown in the drawings or indicated in the sequence of operations. The ASC shall be a single integrated package consisting of a microprocessor, power supply, field terminations, and application software. The units shall be started and stopped from the BMS. A low limit protection thermostat in the mixed air section of the unit shall close down the outdoor air damper, open coil valves, and alarm the BMS when a temperature below 38°F (adjustable) is sensed. All input/output signals shall be directly hardwired to the ASC controller. In all cases, the controller shall automatically resume proper operation following the return of power to, or control by the ASC.

- 1. All ASCs must have an operating temperature range -40°F to 140°F and 5 to 95% RH, non condensing because they are located in the proximity of extreme temperatures (hot water/steam pipes or the outdoor air.)
- 2. All ASCs shall have capability for both ASHRAE Cycle II and ASHRAE Cycle III fully tested and validated. Bidder shall provide application documentation for ASC ASHRAE cycle II and III compliance including sequence of operation, controller program, and available SNVT's. The control program shall also be fully customizable in the field to accommodate any local or project specific requirements that may be required.
- 3. All duct averaging sensors for ASCs must be true continuous averaging units that sense the mean temperature over the complete length of the sensor end to end. Sensors that provide four or nine sensing points, which may be accurate due to air temperature stratifications, are not acceptable.
- 4. All ASCs shall be easily replaceable for ease of future maintenance and to minimize downtime.
- 5. The outputs of the ASC shall be of the relay Form C and universal analog form. All digital outputs shall be relay type Form C. ASC devices utilizing non-relay outputs shall provide an interface relay for all points. All analog outputs shall be programmable for their start points and span to accommodate the control devices.

L. LANs:

Capacity for a minimum of 64 client workstations connected to multi-user, multitasking environment with concurrent capability to access DDC network or control units.

- 1. Enterprise Network LAN
  - a. Media: Ethernet (IEEE 802.3), peer-to-peer CSMA/CD, operating at 10 or 100 Mbps, cable 10 Base-T, UTP-8 wire, category 5
- 2. Primary Controller Network LAN
  - a. Media: LonTalk™ (EIA 709.1), peer to peer, FTT-10 operating at 78.8K.
- 3. Secondary Network LAN ( If Required)
  - a. Media: LonTalk™ (EIA 709.1), peer to peer, FTT-10 operating at 78.8K
- 4. Remote Connection
  - a. ISDN, ADSL, T1 or dial-up connection, monthly charges paid by building owner

M. Software: All Operator Work Station software is existing.

1.16 CONTROL PANELS

- A. Local Control Panels: Unitized NEMA 1 cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.
  - 1. Fabricate panels 0.06-inch thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
  - 2. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL Listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
  - 3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gauges.
  - 4. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

#### 1.17 SENSORS

- A. Electronic Temperature Sensors: Vibration and corrosion resistant for wall, immersion, or duct mounting as required.
  - 1. Resistance Temperature Detectors: Platinum, thermistor, or balco
    - a. Accuracy: Plus or minus 0.2 percent at calibration point; thermistors shall have a maximum 5 year drift of no more than .225°F maximum error of no more than .36°F
    - b. Wire: Twisted, shielded-pair cable
    - c. Insertion Elements in Ducts: Single point, 6 inches long; use where not affected by temperature stratification or where ducts are smaller than 4 sq. ft.
    - d. Averaging Elements in Ducts: 60 inches, long, flexible for use where prone to temperature stratification or where ducts are larger than 4 sq. ft.; 264 inches long, flexible for use where prone to temperature stratification or where ducts are larger than 16 sq. ft; length as required.
    - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
    - f. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
    - g. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
  - 2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
    - a. Accuracy: +/- 1 percent of full scale with repeatability of 0.5 percent.
    - b. Output: 4 to 20 mA, 0-5 vDC, 0-10 vDC.
    - c. Building Static-Pressure Range: -.1 to .1, -0.25 to 0.25, -.5 to .5, -1.0 to 1.0 IN WC., jumper selectable.
    - d. Duct Static-Pressure Range: 0 to 1, 0 to 2.5, 0 to 5, 0 to 10 IN WC., jumper adjustable.
  - 3. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- B. Equipment operation sensors as follows:
  - 1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 IN WC.
  - 2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
  - 3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- C. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

- D. Carbon-Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23°F to 130°F, calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.

#### 1.18 THERMOSTATS

- A. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet
  2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
- B. BTU Meters: Each BTU measurement system is individually calibrated using application specific flow and temperature data and is provided with calibration certifications. Must have an accuracy better than  $\pm 0.15^\circ$  F over calibrated range at the calibrated typical flow rate and within  $\pm 2\%$  of rate over an extended 50:1 turndown range (0.4 - 20 ft/s). All mechanical installation hardware, color coded interconnecting cabling and installation instructions are provided to ensure error-free installation and accurate system performance. Meter must provide highly accurate thermal energy measurement in chilled water, hot water and condenser water systems based on signal inputs from two matched temperature sensors. The BTU Meter will support the following applications:

- University campus monitoring
  - Institutional energy cost allocation
  - Performance/efficiency evaluations
  - Performance contracting energy monitoring
- Acceptable manufacturer: Onicon

#### 1.19 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action under all environmental conditions (temperature, low power voltage fluctuations, tight seal damper design, maximum air and water flow forces).
1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
  2. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2": Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
  3. Spring-Return Motors for Valves Larger Than NPS 2-1/2": Size for running and breakaway torque of 150 in. x lbf.
  4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
  5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
- B. Electronic Damper and Valve Actuators: Direct-coupled type non-hydraulic designed for minimum 100,000 full-stroke cycles at rated torque. The actuator shall have rating of not less than twice the thrust needed for actual operation of the damper or valve
1. Coupling: V-bolt and V-shaped, toothed cradle.
  2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
  3. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
  4. Actuators shall have the ability to be tandem mounted.
  5. All spring-return actuators shall have a manual override. Complete manual override shall take no more than 10 turns.

6. Power Requirements (Two-Position Spring Return): 24V ac or dc, Maximum 10VA.
7. Power Requirements (Modulating): Maximum 15 VA at 24V ac.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: -22°F to 140°F.
10. Run Time: 200 seconds open, 40 seconds closed.
11. All actuators shall have a 5-year warranty.
12. Valves:
  - a. Size for torque required for valve close-off at maximum pump differential pressure (regardless of water loop system pressures).
  - b. Valve and Actuators shall come from the factory fully assembled.
  - c. Spring Return Manual Override shall come with a 10 Degree Valve Preload to assure tight close off.
13. Dampers:
  - a. Size for running torque calculated as follows:
    - 1) Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
    - 2) Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
    - 3) Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. damper.
    - 4) Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
    - 5) Dampers with 2 to 3 Inches wg. of Pressure Drop or Face Velocities of 1000 to 2500 FPM  
Multiply the minimum full-stroke cycles above by 1.5.
    - 6) Dampers with 3 to 4 Inches wg. of Pressure Drop or Face Velocities of 2500 to 3000 FPM  
Multiply the minimum full-stroke cycles above by 2.0.
  - b. Spring Return Manual Override actuators shall have a factory set 5 Degree Damper Preload.

## 1.20 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Globe Valves NPS 2" and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with back seating capacity repackable under pressure. Valves shall have allowable media temperature of 20°F to 281°F to assure that the valve packing will have a long life (valves with narrower allowable media temperatures have no reserve packing capability for long term watertight seal.)
- C. Hydronic system globe valves shall have the following characteristics :
  1. Rating: Class 125 for service at 125 psig. and 250°F operating conditions.
  2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
    - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
  3. Sizing: 3 psig. maximum pressure drop at design flow rate.
  4. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F.
  5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
  6. Product Life: Valve and actuator assembly shall be rated for a minimum of 200,000 cycles and tested for close off prior to delivery.
- D. Control Ball Valves NPS 3" and smaller (NPS 2" for 3-way valves): Forged brass body (CuZn39Pb2), chrome plated brass ball and blowout proof stem and EPDM o-rings with minimum 600 psig. rating. Valve shall contain glass filled ball insert capable of providing equal percentage flow. Valves shall have allowable media temperature of -20°F to 250°F.
  1. Rating: No less than 360 psig. at 250°F operating conditions.
  2. Rangeability: 2-way valves shall have a rangeability of at least 75:1
  3. Medium: Valves shall be used with hot water or cold water with up to 50% glycol.

4. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F.
  5. Sizing:
    - a. Minimum 100 psig. close off on 2 way valves and 70 psig. on three way valves
    - b. Maximum differential shall be 35 psig. to ensure quiet operation.
  6. Flow Characteristics: 2 way valves shall have equal percentage characteristics. 3 way valves shall have an equal percentage characteristic through the control port and a linear characteristic through the bypass port.
  7. Product Life: Valve and actuator assembly shall be rated for a minimum of 200,000 cycles and tested for close off prior to delivery.
- E. Terminal Unit Control Valves: 360 psig. forged yellow brass body, nickel plated brass ball, with optimizer insert for modulating applications, blow-out resistant stem, two or three-port as indicated, and threaded ends for chilled or hot water, up to 50% glycol solutions. Actuators shall be as noted above with 5 year warranty. Spring return is required for all Unit Ventilator heating valves and other terminal equipment that has an outside air source. All non-spring return valves must have manual override ability built in to the actuator.
1. Rating: ANSI class IV, maximum static pressure of 250 psig, minimum fluid temperature of 20°F. and maximum of 250°F operating conditions.
  2. Sizing: 4 psig. maximum pressure drop at design flow rate, to close against pump shutoff head.
  3. Flow Characteristics: Two-way and three-valves shall have equal percentage characteristics.

#### 1.21 DAMPERS

- A. Dampers: AMCA-rated, parallel, opposed blade designs; 0.1084 inch minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635 inch galvanized steel with maximum blade width of .8 inches.
1. Blades shall be secured to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  2. Operating Temperature Range: -40°F to 200°F
  3. For standard applications, include optional closed-cell neoprene edging.
  4. For low-leakage applications, use parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inches wg. when the damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D. Dampers shall be Ruskin CD 50.

#### 1.22 CONTROL CABLE

- A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 16 Section "Control/Signal Transmission Media."
- B. LON communication cable shall be category 4.
1. EXECUTION

#### 1.23 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct, pipe, and equipment mounted devices and wiring are installed before proceeding with installation.

#### 1.24 INSTALLATION

- A. Install equipment level and plumb.

- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure equipment and software to achieve sequence of operation specified.
- D. Verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate all 60 inches above the floor.
  - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- E. Install guards or tamper proof enclosures on thermostats in the following locations:
  - 1. Entrances.
  - 2. Public areas.
  - 3. Where indicated.
- F. Install automatic dampers according to Division 23000 Section "Duct Accessories.
- G. Install damper actuators on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Install labels and nameplates to identify control components according to Division 23000 Section "Basic Mechanical Materials and Methods."
- I. Install labels and nameplates to identify control components according to Division 23000 Section "Mechanical Identification."
- J. Install hydronic instrument wells, valves, and other accessories according to Division 23000 Section "Hydronic Piping."
- K. Install duct volume-control dampers according to Division 23000 Sections specifying air ducts.
- L. Install electronic and fiber-optic cables according to Division 26000 Section "Control/Signal Transmission Media."

#### 1.25 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 26000 Section "Raceways and Boxes."
- B. Install building wire and cable according to Division 26000 Section "Conductors and Cables."
- C. Install signal and communication cable according to Division 26000 Section "Control/Signal Transmission Media."
  - 1. Cable may be installed in plenums where reasonable access is available as allowed by the National Electrical Code and local area codes.
  - 2. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 3. Install exposed cable in raceway.
  - 4. Install concealed and inaccessible cable in raceway.
  - 5. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
  - 6. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
  - 7. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

#### 1.26 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23000 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 1. Install piping adjacent to machine to allow service and maintenance.
- B. 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.

#### 1.27 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.
- B. Replace damaged or malfunctioning controls and equipment.
  - 1. Start, test, and adjust control systems.
  - 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
  - 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- C. Verify DDC as follows:
  - 1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
  - 2. Verify operation of operator workstation.
  - 3. Verify local control units including self-diagnostics.

#### 1.28 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide two Project site visits, as scheduled by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions for one visit addressing summer specific sequences and operations and one visit addressing winter specific sequences and operations. Each site visit will consist of no more than 8 hours not to exceed a total of 16 hours.

#### 1.29 TRAINING

- A. Provided as indicated above, provide a minimum of 16 hours of on-site or classroom training throughout the contract period for personnel designated by the Owner. Each session shall be a minimum of four hours in length and must be coordinated with the building Owner. Train the designated staff of Owners Representative and Owner to enable them to:
  - 1. Proficiently operate the system
  - 2. Understand control system architecture and configuration
  - 3. Understand DDC system components
  - 4. Understand system operation, including DDC system control and optimizing routines (algorithms)
  - 5. Operate the workstation and peripherals
  - 6. Log on and off the system
  - 7. Access graphics, point reports, and logs
  - 8. Adjust and change system set points, time schedules, and holiday schedules
  - 9. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
  - 10. Understand system drawings, and Operation and Maintenance manual

11. Understand the job layout and location of control components
12. Access data from DDC controllers
13. Operate portable operators terminals

### 1.30 SEQUENCE OF OPERATION

- A. VAV Air Handling Unit AH-1 Heating & Cooling Operation:
  1. The unit shall be programmed by manufacturer provided control panel. All damper and valve actuation will be electric. The control panel will include the following:
    - a. Start / Stop
    - b. On / Off status
    - c. Scheduling
    - d. Alarm for component failure
    - e. Filter status via analog differential pressure sensor and dirty filter alarm
    - f. Supply temperature
    - g. Return air temperature
    - h. Mixed outside & return air temperature
    - i. Supply air volume (CFM) via Air Flow Monitoring station
    - j. Return air volume (CFM) via Air Flow Monitoring station
    - k. Outside air volume (CFM) via Air Flow Monitoring station
    - l. Supply air High Static Pressure Limit
    - m. Supply air ductwork system static pressure transmitter
    - n. Space differential pressure transmitter
    - o. Freezestat
  2. Hot Water Heating:
    - a. When the mixed air temperature is below 45°F (adjustable) the hot water control valve shall begin to modulate open. The pump shall stage itself up or down and the supply fan shall modulate to maintain the minimum supply air temperature of 60°F (adjustable).
    - b. In the event of power failure, the hot water valves shall modulate to full open.
    - c. The freeze stat shall be located downstream of the preheat coil. If the freeze stat drops below 35°F, the outside air damper shall close. An alarm shall be sent to the main operator work station.
    - d. In unoccupied mode, the supply air temperature shall reset to 80°F minimum (adjustable).
  3. Cooling mode:
    - a. When the outside air temperature rises above 55°F, the chilled water pump shall be energized. The pump shall stage itself up or down and the supply fan shall modulate to maintain the maximum supply air temperature of 55°F (adjustable).
    - b. When the outside air temperature is between 44°-55°F (adjustable) the outside air dampers shall modulate open to provide outside air economizer cycle.
    - c. In unoccupied mode, the supply air temperature shall reset to 65°F (adjustable).
  4. Automatic air dampers:
    - a. Outside and return air dampers shall modulate to maintain 0.05" wc positive static pressure in the space.
    - b. Relief dampers shall modulate inversely to the position of the outside air dampers.
    - c. If the supply fan stops, the outside air damper shall close.
  5. Supply fan and return fans:
    - a. The supply air fan shall modulate via VFD to maintain constant duct system pressure based on the differential pressure sensor located downstream in the existing medium pressure supply duct at a distance of approximately 2/3 of the total duct length.
    - b. The return fans shall modulate via VFD to maintain positive building static pressure at 0.05" based on the differential pressure sensor to be located at an exterior wall.
  6. Smoke Detectors:
    - a. In the event of smoke detection by the supply air smoke detector or the return air smoke detector, the unit will shut down and an alarm will be sent to the main operator workstation. The outside air dampers shall close and return air dampers shall close.
  7. Outside air dampers:

- a. In occupied mode the outside air dampers shall be set at a minimum open position so that the sum total intake air volume of both dampers shall be equal to the minimum outside air listed on the Air Handler Schedule.
  - b. In unoccupied mode the unit shall run in the setback mode with outside air dampers closed.
- B. AH-2 Heating & Cooling Operation:
1. The unit shall be programmed by manufacturer provided control panel. The control panel will include the following:
    - a. Start / Stop
    - b. On / Off status
    - c. Scheduling
    - d. Alarm for component failure
    - e. Filter status via differential pressure sensor and dirty filter alarm
    - f. Supply temperature
    - g. Exhaust air temperature
    - h. Outside air temperature
    - i. Supply air volume (CFM) via Air Flow Monitoring station
    - j. Return air volume (CFM) via Air Flow Monitoring station
    - k. Outside air volume (CFM) via Air Flow Monitoring station
    - l. Supply air High Static Pressure Limit
    - m. Supply air ductwork system static pressure transmitter
    - n. Space differential pressure transmitter
    - o. Freezestat
  2. Hot Water Heating:
    - a. When the outside air temperature is below 45°F (adjustable) the hot water control valve shall begin to modulate open. The pump shall stage itself up or down and the supply fan shall modulate to maintain the minimum supply air temperature of 90°F (adjustable).
    - b. In the event of power failure, the hot water valves shall modulate to full open.
    - c. The freeze stat shall be located downstream of the heating coil. If the freeze stat drops below 35°F, then the supply fan shall stop, and outside air damper shall close. The hot water heating valve shall modulate to full open.
    - d. In unoccupied mode, the supply air temperature shall reset to 80°F minimum (adjustable).
  3. Cooling mode:
    - a. When the outside air temperature rises above 55°F, the chilled water pump shall be energized, and the chilled water control valve shall modulate open. The pump shall stage itself up or down and the supply fan shall modulate to maintain the maximum supply air temperature of 58°F (adjustable).
    - b. In unoccupied mode, the supply air temperature shall reset to 65°F (adjustable).
  4. Automatic air dampers:
    - a. Exhaust air dampers shall modulate to maintain 0.05" wc positive static pressure in the space.
    - b. If the supply fan stops, the outside air damper shall close.
  5. Supply air fan and exhaust air fans:
    - a. The supply fan shall modulate via VFD to maintain constant duct system pressure based on the differential pressure sensor located downstream in the supply duct at a distance of approximately 2/3 of the total duct length.
    - b. The exhaust fan shall modulate via VFD to maintain positive building static pressure at 0.05" based on the differential pressure sensor to be located at the exterior wall.
    - c. In the unoccupied mode, the supply fan shall modulate to the minimum fan speed setting as recommended by the manufacturer. The exhaust fan shall modulate to maintain static pressure as listed in item b. above.
  6. Smoke Detectors:
    - a. In the event of smoke detection by the supply air smoke detector or the return air smoke detector, the unit will shut down. The outside air dampers shall close and exhaust air dampers shall close.
  7. Outside air dampers:
    - a. In occupied mode the outside air dampers shall be set at full open position.

- b. In unoccupied mode the unit shall run in the setback mode with outside air dampers at the minimum open position.
- C. EF-1 Operation:
  - The exhaust fan shall operate continuously at constant speed.

END OF SECTION

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Plumbing and HVAC system pumps, except where provided as integral part of manufactured piece of equipment, including:
  - 1. Vertical in-line.

## 1.02 INFORMATIONAL SUBMITTALS

- A. Shop Drawings including:
  - 1. Pump curves.
  - 2. Materials of construction.
  - 3. Schedule of pumps.
  - 4. Performance characteristics.
  - 5. Data concerning physical dimensions.
  - 6. Motor drive assemblies.
  - 7. Bearings.
  - 8. Seals.
  - 9. Impellers capacities.
  - 10. Weights.
  - 11. Ratings.

**PART 2 PRODUCTS**

## 2.01 DESIGN REQUIREMENTS

- A. Statically and dynamically balance rotating parts.
- B. Construction shall permit complete servicing without breaking piping or motor connections.
- C. Pumps shall operate at 1,750 rpm unless otherwise noted.
- D. Pump connections:
  - 1. 3/4"-2": Threaded or flanged.
  - 2. 2-1/2" or larger: Flanged.
- E. Heating pumps shall be suitable for handling fluids at 230°F.

## 2.02 VERTICAL IN-LINE PUMP

- A. Service: See schedule on Drawings.
- B. Type: Centrifugal, single-stage, close coupled in-line, back pullout design, suitable for horizontal or vertical operation.
- C. Casing: Cast iron, rated for greater of 125 psi (862 kPa) or 1.5 times actual discharge working pressure, suction and discharge gage port, air vent, wear rings, seal flush connection, drain plug.
- D. Impeller: Bronze, fully enclosed, keyed to shaft and secured with locknut.
- E. Shaft: Stainless steel with bronze or stainless steel sleeve through seal chamber.
- F. Seals: Carbon rotating against a stationary ceramic seat.

- G. Seals: Packing gland with minimum 4 rings Teflon impregnated packing. Manufacturer: Bell & Gossett Series 80 or equal by Armstrong, or Taco.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION - GENERAL**

- A. Set base-mounted pumps on inertia bases above grade, level and bolt down prior to filling entire base with nonshrinking grout.
- B. Align base-mounted pumps after mounting and grouting. Maximum allowable misalignment between pump and motor not to exceed 0.004" in both axial and angular planes. Pin with minimum of 3 taper pins to base for each pump and motor.
- C. Where pump connections and line sizes do not match, provide concentric reducers/increasers at pump connections in vertical and eccentric connections in horizontal.
- D. Valves and piping specialties shall be full line size not pump inlet or outlet size.
- E. Install line size gate valve and strainer and minimum 5 pipe diameters straight run of pipe to suction side of pump. Pump suction diffuser may be used instead of straight pipe requirement.
- F. Provide 3/4" Type K hard copper drains for bases and stuffing boxes and drip pans piped to and discharging into floor drains.
- G. Provide air cock and drain connection on horizontal pump casings.
- H. Provide line sized butterfly valve, flexible connector, and strainer on suction and line sized spring-loaded check valve butterfly valve and orifice plate flow meter and calibrated balance valve, flexible connector on discharge.
- I. Decrease from line size with eccentric reducers. Support piping adjacent to pump such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4" and over.
- J. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are nonoverloading in parallel or individual operation; operate within 25% of midpoint of published maximum efficiency curve.
- K. Qualified millwright shall check, align, and certify base mounted pumps prior to startup.
- L. Access: Provide access space around pumps for service indicated, but in no case less than that recommended by manufacturer.
- M. Support:
  - 1. Install base-mounted pumps on minimum \*4" \*6" high concrete base equal, with anchor bolts poured in place, and extending 6" beyond equipment in all directions.
  - 2. Set and level pump, grout under pump base with nonshrink grout.
- N. Sump pump basins:
  - 1. Install sump pump basins in indicated locations and connect to sewer inlets.
  - 2. Brace interior of basin in accordance with manufacturer's instructions to prevent distortion or collapse during concrete placement.
  - 3. Refer to Division 3 for concrete work.
  - 4. Set cover over basin, fasten to top flange of basin.
  - 5. Install so cover is flush with finished floor \*or equipment basin.\*

### 3.02 ELECTRICAL WIRING

- A. Install electrical devices furnished by manufacturer but not specified to be factory-mounted.
- B. Furnish copy of manufacturer's wiring diagram submittal to Division 26 installer.
- C. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26.
- D. Do not proceed with equipment start-up until wiring installation is acceptable.
- E. Responsibility: Section providing equipment.

### 3.03 FIELD QUALITY CONTROL

- A. Upon completion of installation of pumps, and after motors have been energized with normal power source, bleed air from pump casings and test pumps to demonstrate compliance with specifications.
- B. Where possible, field correct malfunctioning unit, then retest to demonstrate compliance.
- C. Replace units which cannot be satisfactorily corrected.
- D. Alignment: Inspect alignment, and realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
- E. Start-up:
  - 1. Lubricate pumps before start-up.
  - 2. Start-up in accordance with manufacturer's instructions.
  - 3. Provide pump start-up in presence of manufacturer's service representative.
- F. Cleaning:
  - 1. Clean factory-finished surfaces.
  - 2. Repair marred or scratched surfaces with manufacturer's touch-up paint.

### 3.04 PUMP SCHEDULE

- A. See schedules on Drawings.

END OF SECTION

### 1.01 SECTION INCLUDES

- A. Metal ducts.
- B. Double wall.
- C. Duct lining.

### 1.02 DEFINITIONS

- A. Duct sizes: Inside clear dimensions. For acoustically lined or internally insulated ducts, maintain scheduled sizes inside lining or insulation.
- B. Pressure class:
  - 1. See application table for pressure class requirements for each duct system.
  - 2. Pressure classes shall correspond to pressure classes defined by SMACNA in HVAC Duct Construction Standards Metal and Flexible – Third Edition.
  - 3. Each pressure class shall be suitable for positive or negative pressure applications.

### 1.03 PERFORMANCE REQUIREMENTS

- A. Guarantee ductwork to be free of vibration, chatter, objectionable pulsation, and excessive leakage under all conditions of operation.

### 1.04 INFORMATIONAL SUBMITTALS

- A. Shop Drawings: Duct fittings, including particulars such as gage sizes, welds, and configurations.
- B. Samples: Duct fittings.

### 1.05 QUALITY ASSURANCE

- A. Use material, weight, thickness, gage, construction, and installation methods as outlined in following SMACNA publications:
  - 1. SMACNA Duct Construction Standards Metal & Flexible, Third Edition.
  - 2. SMACNA Fibrous Glass Duct Construction Standards, Seventh Edition.
- B. Construct and install ductwork in accordance with provisions of \*Uniform Mechanical Code\*  
\*International Mechanical Code\*.
- C. Verify field measurements prior to fabrication.

## PART 2 PRODUCTS

### 2.01 MATERIALS

- A. Galvanized sheet steel:
  - 1. Cold-rolled, soft sheet steel capable of double seaming without fracture.
  - 2. Zinc coating: G90 in accordance with ASTM A653 and ASTM A90.
- B. Paintable galvanized sheet steel:
  - 1. Cold-rolled, soft sheet steel capable of double seaming without fracture.
  - 2. Zinc coating: G90 in accordance with ASTM A653 and ASTM A90.
  - 3. Duct surface shall undergo mil phosphatizing process in accordance with ASTM D2092 to prep ductwork for painting.

- C. Sealant:
  - 1. Water-based, water-resistant.
  - 2. Fire-resistive.
  - 3. Compatible with mating materials.
  - 4. Elastomeric mastic
  - 5. Maintain manufacturer's recommended temperatures during and after installation.

## 2.02 MANUFACTURED DUCTWORK

- A. Type: Double-wall.
- B. Outer shell: ASTM A653 galvanized sheet steel.
- C. Inner lining: Perforated ASTM A653 galvanized sheet steel, 22% open area.
- D. Insulation: 1" (25 mm) thick glass fiber insulation. Insulation shall meet requirements of glass fiber duct lining specified in this section.
- E. Fittings: Machine-formed, 1.5 centerline radius or sectional.
- F. Internal bracing: Not acceptable.
- G. Provide shipping braces or rigid duct connectors to retain proper shape during shipping. If shipping braces are used, remove before installation of duct.
- H. Manufacturer: McGill Airflow "Accousti-k27 Duct," or equal.

## PART 3 EXECUTION

### 3.01 FABRICATION AND INSTALLATION

- A. Fabricate and install duct, fittings, reinforcement, and supports in accordance with SMACNA recommendations except as modified below.
  - 1. Complete metal ducts within themselves with no single partition between ducts. Where width of duct exceeds 18" (450 mm), cross break for rigidity. Open corners are not acceptable.
  - 2. Increase duct sizes gradually, not exceeding 15° divergence wherever possible. Maximum divergence upstream of equipment shall be 30°; convergence downstream of equipment shall be 45°.
  - 3. Provide easements where ductwork conflicts with piping and structure. Where easements exceed 10% of duct area, split into two ducts maintaining original duct area.
- B. Ductwork - general:
  - 1. Construct ductwork so interior surfaces are smooth. Use rivets or nuts and bolts for fabricating ductwork. Sheet metal screws may be used on duct hangers, transverse joints, and other SMACNA-approved locations if screw does not extend more than 1/2" (15 mm) into duct. Seal fastener locations where leakage could occur and seal ductwork according to SMACNA recommendations with regard to pressure class of duct.
  - 2. Use elbows, tees, lateral, crosses and accessory fittings as needed to fabricate duct systems.
  - 3. Use elbows and tees with a centerline radius to width or diameter ratio of 1.5 wherever space permits. When shorter radius must be used due to limited space, install sheet metal turning vane through entire length of fitting. Where space will not allow use of shorter radius elbow or tee, install mitered fitting with double-wall turning vanes. Square throat-radius heel elbows shall not be acceptable.
  - 4. Construct branch take off with 45° take off fitting connection 1-1/2 times area of branch duct.

5. Use splitter dampers and/or extractors only where manual volume dampers will not accomplish intended balancing. Use of splitter dampers and/or extractors shall not eliminate need for specified or indicated manual volume dampers.
  6. Lap metal ducts in direction of air flow. Hammer down edges and slips to leave smooth duct interior.
  7. Rigidly construct metal ducts with joints mechanically tight, substantially airtight, braced and stiffened so as not to breathe, rattle, vibrate, or sag.
  8. Fasten hangers to duct with nuts and bolts or surround duct with hanger strap to provide a single hanging point for round duct. Trapeze hangers may be used. Internal duct hangers not accepted.
  9. Provide sufficient clearances between duct and beams, pipes, or other obstructions in building construction and for work of other trades. Check drawings showing work of other trades and consult with Engineer in event of any interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on Drawings. Where it is necessary to take pipes or similar obstruction through ducts, ducts need not be enlarged if decrease in area does not exceed 10%. If decrease in area would exceed 10%, enlarge duct to maintain duct area not less than 90%. In all cases, provide a streamlined casement or collar designed in accordance with SMACNA and seal to prevent air leakage.
  10. Provide frames constructed of angles or channels for coils, filters, dampers, or other devices installed in duct systems, and make connections to such equipment including equipment furnished by others. Secure frames with felt gaskets, nut, bolts, and washers.
  11. Remove dirt and foreign matter from entire duct system and clean diffusers, registers, and grilles before operating fans and/or before balance begins.
  12. Install motor-operated dampers and connect to or install equipment furnished by others.
  13. At outside air intakes, install duct to pitch to intakes and to drain to outside of building. Solder or caulk on airside seams to form watertight joints. Blank off unused portions of louvers with 1-1/2" (40 mm) board insulation with galvanized sheet metal backing on both sides.
  14. Seal transverse joints and all seams.
  15. Sealant shall be installed as recommended by manufacturer.
  16. Use of tape without sealant shall not be acceptable
- C. Ductwork 3" (750 Pa) pressure class and greater:
1. Fabricate and install ductwork, fitting, and reinforcement in accordance SMACNA recommendations.
  2. Field joints shall be slip type with sealer applied between joints and riveted. Apply 2" (50 mm) band of duct sealer on outside of joint and duct tape.
  3. Use of splitter dampers and/or extractors not allowed.
  4. Use elbows, tees, lateral, crosses and accessory fittings as needed to fabricate duct systems.
  5. Provide positive and negative relief fittings.
  6. Seal all joints, seams and wall penetrations.
- D. Duct pressure test:
1. Pressure test ductwork with Contractor-furnished calibrated test apparatus. Conduct test at pressure rating of duct section, record data in a neat manner before allowing duct to be insulated. Leakage rate shall not exceed more than 1% of system air quantity for 10" w.g. pressure class ductwork or 5% of system air quantity for ductwork 6" w.g pressure class and below. Locate leak sources, repair, and retest when necessary.
  2. If air leakage more than specified above is found during pressure testing and/or air balancing, locate and seal source of leakage. Repair any damage to insulation or other construction.
- E. Hangers and supports:
1. Support rigid round, rectangular, and flat oval metal ducts with support systems indicated in "Hangers and Supports" chapter of SMACNA Duct Construction Standards.
  2. Provide supports as required to maintain alignment.
  3. Provide additional supports within 2' (0.6 m) of each elbow and 4' (1.2 m) of each branch intersection.

- F. Seismic restraint of ducts: Provide seismic restraint of all ducts in accordance with SMACNA Seismic Restraint Manual (1998 Edition with Addendum 1), and in accordance with local Building Code. Seismic Hazard levels shall be Zone 4.
  
- G. Duct liner
  - 1. Apply liner with 100% coverage of fire-resistant adhesive, stick clips or weld pins on minimum 15" (375 mm) centers.
  - 2. Mechanical fasteners shall be installed flush with liner surface with pins clipped back to each fastener.
  - 3. Coat leading edge of liner cross joints and damaged areas with a heavy layer of fire-resistant adhesive.
  - 4. Install sheet metal foil at termination of liner.
  - 5. Where duct velocity exceeds 2000 fpm (10 m/s) provide metal nosing on all upstream edges of duct liner.
  
- H. Sealing requirements:
  - 1. All ducts:
    - a. Seal transverse joints and all seams.
    - b. Sealant shall be installed as recommended by manufacturer.
    - c. Use of tape without sealant shall not be acceptable
  - 2. 3" (750 Pa) and higher pressure class
    - a. Seal all joints, seams and wall penetrations.
    - b. Sealant shall be installed as recommended by manufacturer
    - c. Use of tape without sealant shall not be acceptable.
  
- I. Premanufactured ductwork:
  - 1. Fabricate as specified in paragraph "Fabrication" in this Section.
  - 2. Install in accordance with manufacturer's requirements
  - 3. Manufactured duct sections shall be guaranteed completely leakproof. Field joints shall be assembled airtight and shall be additionally calked or soldered if required.

3.02 APPLICATION

Duct Application	Duct Material	Minimum Pressure Class	Insulation
Supply between fans and high velocity terminal devices	Galvanized: Concealed or exposed in mechanical / electrical rooms	6 " w. g. (1500 Pa)	Rectangular: 1" (25 mm) lining
Supply between fans and VCU's	Paintable galvanized: Exposed	6 " w. g. (1500 Pa)	Round: Section 20 07 00
Supply downstream of VCU's	Galvanized: Concealed or exposed in mechanical / electrical rooms	2 " w. g. (500 Pa)	Rectangular: 1" (25 mm) lining
Return/Relief	Paintable galvanized: Exposed	2 " w. g. (500 Pa)	Round: Section 20 07 00
Exhaust	Galvanized: Concealed or exposed in mechanical / electrical rooms:	2 " w. g. (500 Pa)	Rectangular: 1" (25 mm) lining
Exhaust	Paintable galvanized: Exposed	2 " w. g. (500 Pa)	Round: Section 20 07 00
Outdoor air	Galvanized	2 " w. g. (500 Pa)	Section 20 07 00
Exterior, locker rooms	Aluminum	2 " w. g. (500 Pa)	Section 20 07 00
Underground	PVC coated	10 " w. g. (2500 Pa)	None
Kitchen grease exhaust	Carbon steel or stainless steel	NA	None

Duct Application	Duct Material	Minimum Pressure Class	Insulation
Chemical rooms	Stainless steel or FRP	NA	None
Kitchen grease exhaust	Doubled-walled factory built grease duct	NA	Minimum 3" ceramic fiber between walls
Ducts not indicated above	Galvanized: concealed or exposed in mechanical / electrical rooms	2 " w. g. (500 Pa)	Rectangular: 1" (25 mm) lining
	Paintable galvanized: Exposed	2 " w. g. (500 Pa)	Round: Section 20 07 00

## A. Duct lining:

Type of Duct	Duct Location	Location of Lining in Duct	Length	Thickness, inch (mm)
Supply Duct	Indoors	AHU Outlet	10 feet min	1 (25)
Return Duct	Indoors	Return Fan Inlet and Outlet	10 feet min	1 (25)
Vent Relief	Indoors	Return Fan Outlet	none	1 (25)
Exhaust Duct	Indoors	EF-X, Inlet	none	1 (25)

## B. Do not apply duct lining to following ductwork:

1. Exhaust systems ductwork.

END OF SECTION

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. Access doors.
- B. Fire, balancing, and backdraft dampers.
- C. Flexible connections.
- D. Turning vanes.
- E. Flexible duct.
- F. Intake and relief hoods.
- G. Extractors.
- H. Air mixing devices.
- I. Prefabricated roof curbs.

### 1.02 INFORMATIONAL SUBMITTALS

- A. Shop Drawings: Data concerning dimensions, capacities, ratings and appropriate identification.
- B. Product Data: Manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

### 1.03 QUALITY ASSURANCE

- A. Manufacturer's qualifications: Manufacturers must have at least 5 years experience manufacturing duct accessories, of required types and sizes and whose products have been satisfactory used in similar service.
- B. Regulatory requirements:
  - 1. Fire dampers: UL-listed and constructed in accordance with UL 555.
  - 2. Fusible links: UL-listed and constructed in accordance with UL 33.
  - 3. Access doors: UL-listed.
  - 4. Use material, weight, thickness, gage, construction, and installation method as outlined in:
    - a. SMACNA Duct Construction Standards - Metal & Flexible, Second Edition.
    - b. UBC, 1997 Edition.
  - 5. NFPA 90A - Standard for Air Conditioning and Ventilating Systems.
  - 6. NFPA 90B - Standard for Installation of Warm Air Heating and Air Conditioning Systems.
  - 7. UL 214 - Test for Flame-Propagation of Fabrics and Films.

## **PART 2 PRODUCTS**

### 2.01 ACCESS DOORS

- A. Fabricate rigid and close fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum 1/2" (13 mm) thick insulation with sheet metal cover.
- B. Provide 1 hinge and 1 sash lock for sizes up to 12" (300 mm) square.

- C. Units shall be suitable for duct pressure class in which it is to be installed.
- D. Manufacturer: Ventfabrics Inc., Ruskin, or equal.

#### 2.02 FIRE DAMPERS

- A. Housing: Galvanized steel.
- B. Rating: 1-1/2-hour, Type B.
- C. Blade: Folding, steel, 100% out of air stream.
- D. Fusible link: 165°F (74°C).
- E. Manufacturer: Air Balance Inc, Ruskin, or equal.

#### 2.03 BALANCING DAMPERS

- A. Provide with locking hand quadrant with damper position indicator.
- B. Construction: Bolted.
- C. Frames: Minimum 0.25" (6 mm) thick extruded aluminum channel.
- D. Blades: Double-skin airfoil design, maximum 7-3/4" (197 mm) wide, galvanized steel.
  - 1. Blade length up to 48": Minimum 16-gage (1.5 mm).
  - 2. Blade length 48" to 60": 14-gage (1.8 mm).
- E. Axles: Minimum 3/4" (19 mm) diameter plated steel rod.
- F. Bearing: Stainless steel sleeve pressed into cast housing and bolted to damper frame.
- G. Provide dampers more than 12" (300 mm) in height with channel frames; opposed blade linkage operation; 14-gage (1.8 mm) minimum; 8" (200 mm) maximum width. Linkage shall be out of air stream.
- H. For ducts to 12" (300 mm) in height, single blade type may be used.
- I. Construct dampers over 48" (1.2 m) in width in multiple sections with mullions.
- J. Manufacturer: Air Balance Inc., Ruskin, American Air Warming, or equal.

#### 2.04 BACKDRAFT DAMPERS

- A. Type: Multiblade, counterbalanced type; suitable for flange and gasket connection to ductwork.
- B. Frames: Minimum 20-gage (0.9 mm) galvanized steel channel.
- C. Blades: 28-gage (0.4 mm) galvanized steel
- D. Axles: Minimum 1/2" (13 mm) diameter, synthetic, full length.
- E. Bearing: Nylon.
- F. Seals: Vinyl gasket blade edge seals,

- G. Manufacturer: Air Balance Inc., Ruskin, or equal.

## 2.05 FLEXIBLE CONNECTIONS

- A. Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment
- B. Material: Fire-retardant, waterproof, airtight, and comply with UL 214 and NFPA 90A; 30 oz/sq yd, closely woven glass fabric, double coated with neoprene.
- C. Flexible connection fabric shall be approximately 2" (50 mm) wide tightly crimped into metal edging strip and attach to ducting and equipment by screws or bolts at 6" (150 mm) intervals.
- D. Manufacturer: Ventfabrics, Inc., Duro Dyne Corp., The Flexaust Co., or equal.

## 2.06 TURNING VANES

- A. Fabricated turning vanes and vane runners: Construct in accordance with SMACNA "SMACNA Duct Construction Standards - Metal & Flexible, "
- B. Manufactured turning vanes: Construct of 1" (25 mm) wide curved blades set at 3/4" (19 mm) oc, supported with bars perpendicular to blades set at 2" (50 mm) oc, and set into side strips suitable for mounting in ductwork.
- C. Acoustic turning vanes: Construct of airfoil shaped aluminum extrusions with perforated faces and fiberglass fill.
- D. Material of construction:
1. Vanes: 26-gage (0.5 mm), hot-dipped galvanized steel, furnished in 10' (3 m) lengths.
  2. Side rail: 24-gage (0.6 mm), hot-dipped galvanized steel, furnished in 100' (30 m) coils with fasteners, assembly slots are located on design center spacing of 2.4" (61 mm).
- E. Vanes shall be adjustable as an assembly. Attach vanes to side rails by fasteners through slots. Vanes in assembly shall move together as correct alignment is made for elbow, maintaining leading and trailing edges in exact parallel relationship.
- F. Manufacturer: Aero/Dyne Co.; Airsan Corp.; Tuttle and Bailey; Hart & Cooley Mfg. Co.; Register & Grille Mfg. Co., Inc.; or equal.

## 2.07 FLEXIBLE DUCT

- A. Inner liner: Glass fiber, PVC coating, factory-clinched in cold-rolled galvanized steel spiral, or with spiral wire permanently bonded to fabric, UL-listed, NFPA 90.
- B. Outer jacket: 1-1/2" (38 mm) thick, 3/4 lb (0.3 kg) fibrous glass, with flame-resistant PVC vapor barrier.
- C. Suitable for -20° to 220°F (-29 to 104°C) temperature range, and minimum 6" (150 mm) wc working pressure.
- D. Manufacturer: Duro Dyne Corp., Thermaflex, The Flexaust Co., or equal.

## 2.08 INTAKE AND RELIEF HOODS

- A. Type: Louvered penthouse.

- B. Materials of construction: Extruded aluminum.
- C. Accessories: Birdscreen, insect screen, counter weighted gravity operated backdraft damper.
- D. Manufacturer: Penn Ventilator Company "Pennhouse," or equal.

#### 2.09 EXTRACTORS

- A. Size: As required to suit supply duct takeoff.
- B. Material of construction: Galvanized steel.
- C. Manufacturer: Titus Products, or equal.

#### 2.10 AIR MIXING DEVICES

- A. Construction: Not less than 0.08" (2 mm) aluminum, all-welded construction.
- B. Units shall be of size, capacity, and pressure drop as scheduled.
- C. Performance: Units shall provide mixed air temperatures and velocities within 10% of theoretical values at inlet side of preheat coil.
- D. Manufacturer: Blender Products, Inc., or equal.

#### 2.11 PREFABRICATED ROOF CURBS

- A. Construction: 55% aluminum-zinc coated sheet, all-welded.
- B. Insulation: 1-1/2" (38 mm) thick neoprene coated, 1-1/2 lb/cu ft (24 kg/cu m) density, rigid fiberglass.
- C. Accessories: Wooden nailing strips.
- D. Height: 12" (300 mm) minimum.
- E. Manufacturer: Haakon, Trane, Greenheck Fan Corporation , Roof Products, Inc, Metallic Products Roof Curbs, or equal.

#### 2.12 PREFABRICATED ROOF RAILS

- A. Material: 18-gage (1.2 mm) galvanized steel, welded.
- B. Corners: Mitered and continuously welded.
- C. Wood: Treat with high-quality wood preservative.
- D. Height of rail above top surface of deck: 1'-0" (300 mm).
- E. Size: As required for use with mechanical equipment supplied.
- F. Finish: One coat of standard rust-inhibitive primer.
- G. Provide rail with 1/2" (13 mm) external rigid fiberboard insulation.
- H. Provide auxiliary framing members for rails to transfer equipment load to adjacent roof framing members.

- I. Manufacturer: Pate Manufacturing Co., Fast Curbs, or equal.

### **PART 3 EXECUTION**

#### **3.01 APPLICATION**

- A. Access doors: Provide for cleaning and inspection before and after automatic dampers, fire dampers, and elsewhere as indicated. Size shall be sufficient to perform intended service.
- B. Fire dampers:
  1. Install in strict accordance with manufacturer's installation instructions.
  2. Where indicated and where required by authorities having jurisdiction.
  3. Install complete with mounting collars, retaining angles, and duct access doors.
  4. Provide label on ceiling or adjacent to damper mounted on duct where duct is exposed, identifying damper location.
- C. Backdraft dampers: Install where indicated and in discharge of each exhaust fan except where motor-operated dampers are shown or specified.
- D. Manual balancing dampers:
  1. Install in branch ducts of supply, return low-pressure ductwork.
  2. Install as far upstream from inlet or outlet as possible.
- E. Duct flexible connections:
  1. Install for connections of ductwork to equipment casing, including air handling units, fans and fan coils, where fan is not isolated from equipment casing.
  2. Installed width shall be not less than 4" (100 mm).
- F. Turning vanes:
  1. Install in 90° mitered elbows.
  2. Install in accordance with manufacturer's or SMACNA recommendations.
- G. Flexible duct:
  1. Maximum length shall be not greater than 3'-0" (900 mm), unless otherwise indicated.
  2. Connections shall be accomplished with collars, clamps, and sealer on inside of duct.
  3. Do not install flexible ductwork where ductwork is exposed to view.
  4. Install flexible duct in fully extended manner with no kinks and no more than equivalent of two 90° bends.
- H. Intake and relief hood:
  1. Install in accordance with manufacturer's instructions.
  2. Units indicated for future service shall have removable, insulated steel cap installed between roof curb and shall provide positive weather seal until unit is placed in active service.
- I. Extractors:
  1. Install in ductwork \*as shown\* or \*where required by balancing contractor if balancing damper will not accomplish intended function\*.
  2. Do not install in high-pressure ductwork.
- J. Air mixing devices:
  1. Install air blenders as indicated on Drawings and as scheduled.
  2. Install minimum of one air blender diameter upstream of next item in airstream.
  3. Install in accordance with manufacturer's instructions.
- K. Prefabricated roof curbs: Install in accordance with manufacturer's recommendations and roofing system manufacturer.

END OF SECTION

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Penthouse construction and supply and exhaust fans.

1.02 SYSTEM DESCRIPTION

- A. Contractor shall have option of following construction methods:
  - 1. Install mechanical penthouse and field install fans, coils, furnace, and wiring.
  - 2. Factory install fans, coils, furnace, and wiring prior to shipping to project site.

1.03 SUBMITTALS

- A. Submit Shop Drawings on all operating equipment including compressors, motors, variable speed drives, fans, dampers, coils, vibrations isolators, access doors, controls, and louvers.
- B. Submittals shall include unit capacities, manufacturer, pressure/flow/temperature ratings, model number, and other data sufficient to fully identify and purchase replacement part.
- C. Submittals shall include warranties on all parts.

1.04 QUALITY ASSURANCE

- A. Penthouse manufacturer shall have at least 5 years experience in the construction of these type of units and shall have built units of similar size and capacity as shown on schedule.

**PART 2 PRODUCT**

2.01 ACCEPTABLE MANUFACTURERS

- A. Haakon.
- B. Temptrol.
- C. Trane.
- D. York.
- E. Unitech.
- F. Energy Labs.

2.02 CUSTOM AIR HANDLING UNIT

- A. Unit shall be of the type, size, and capacity as required and listed in equipment schedule. Unit shall include components consisting of following equipment:
  - 1. Supply fans, exhaust fans.
  - 2. Supply VFD, exhaust VFD.
  - 3. Cooling coils.
  - 4. Gas heater.
  - 5. Filters.
  - 6. Condensing unit.
  - 7. Controls.
  - 8. Control dampers.

9. Louvers.

B. Cabinet and frame:

1. The unit base frame shall be fabricated with 6-inch, 10½ lb. per foot, structural steel C-channel.
2. Structural cross members shall be placed at critical locations to support internal components.
3. Vertical frame members shall be fabricated from formed 11-gauge channels.
4. The unit base frame shall be furnished with lifting lugs capable of accepting cable or chain hooks for rigging.
5. Prior to unit assembly, the entire frame shall be covered with a minimum one-mil coat of air-dried sandstone rust inhibiting coating for maximum corrosion protection.
6. Internal floor liners shall be fabricated from 14-gauge galvanized steel welded to the base frame and sealed to prevent air leakage.
7. The entire unit length shall include an underliner constructed of 18 gauge galvanized steel to contain insulation and provide additional structural support.
8. The air handler cabinet casing shall utilize double wall sandwich construction.
9. The exterior surfaces of the wall shall form the air seal and shall be fabricated from 18 gauge galvanized steel.
10. The interior shall be lined with 20 gauge galvanized steel.
11. The exterior panels shall be galvanized steel, pre-coated with 1 mil of sandstone baked polyester coating which will withstand 1,000 hours of salt spray per ASTM B-117 over an epoxy primer.
12. The unit base shall be insulated with 4-inch, 1-pound density of fiberglass insulation.
13. Wall and roof panels shall be insulated with 4-inch, 1 pound density fiberglass with a minimum R-value of 6.9. Compressing 2" insulation between 1" panels is not acceptable.
14. Exterior roof panels shall be crowned for drainage and easily removable for service access.

C. Access doors:

1. A full-size hinged access door shall be provided for any section requiring service access. Removable casing panels shall not be allowed. Access doors shall be minimum 24" wide, and maximum 60" wide.
2. Door frame shall be of rigid extruded aluminum. Adhesive-backed gasket applied to the frame shall not be allowed.
3. Access doors shall be thermally broken and provided to the following components at a minimum:
  - a. supply and return fan motors,
  - b. supply and return fan inlets, filters, dampers, cooling coils and any other serviceable component.
4. Hinged access doors shall be complete with stainless steel hinges and multiple-point, single-handle compression-type latches to provide quick access without the use of tools and a positive air seal. Latch shall include integral keyed lock. Interior latch allows door closure during inclement weather. Doors shall include locking type door retainers to protect doors against wind damage when open. Door sizes shall be as shown on the plans.
5. Access doors shall also be provided for the gas heater vestibule, VFD control panel, evaporative condenser vestibule, and main control panel. Door sizes shall be as shown on the plans.
6. Door safety restraints provide a ½-turn secondary latch which shall prevent unwanted rapid door opening against high interior pressures.
7. Each door shall include a view port to allow visual inspection of interior components.

2.03 COMPRESSORS

- A. The compressor shall utilize an orbiting scroll with axial and radial compliance for compression.
- B. Compressors shall be high efficiency, suction-gas cooled, single speed, hermetic type, with three Teflon bearings and a cast iron motor frame.
- C. Compressors shall be mounted on rubber-in-shear isolators.
- D. The compressor circuit shall include high and low pressure taps, a discharge service valve, and a check valve at the discharge outlet to prevent reverse rotation.

- E. Compressors shall have internal motor protection for over-temperature and over-current conditions.
- F. Other safety devices include:
  - 1. Crankcase heater,
  - 2. High-pressure cutout, and
  - 3. Low suction pressure freeze protection.
- G. Capacity reduction shall be performed with compressor staging and hot gas bypass on tandem compressor models.
- H. Capacity reduction shall be performed with hot gas bypass on non-tandem compressor models.
- I. Compressor shall include a 5 year warranty.

#### 2.04 ELECTRONIC TEMPERATURE-CONTROLLED HOT GAS BYPASS

- A. A temperature-controlled modulating hot gas bypass valve will trim the #1 compressor's effective capacity.
- B. The valve shall be controlled between each and every compressor control stage.
- C. The valve follows the cooling demand and must be commanded fully closed before a compressor stage is enabled and commanded to its maximum open position (adjustable) before a stage is disabled. A mechanical hot gas bypass valve will also be supplied as a safety mechanism.

#### 2.05 REFRIGERATION CIRCUIT SPECIALTIES

- A. Each independent refrigerant circuit shall be completely piped, tested, dehydrated, and fully charged with oil and refrigerant R410a.
- B. Each refrigerant circuit includes compressor, condenser with integral liquid sub-cooler, liquid line service and charging valve, filter drier, removable core with valved bypass, solenoid valve, sight glass, fusible plug, and thermostatic expansion valve.

#### 2.06 EVAPORATOR COIL

- A. Construction
  - 1. Direct expansion coil shall be constructed of ½-inch seamless copper tubes expanded into aluminum or copper fins and shall not be less than three rows in depth, nor have more than 12 fins per inch.
  - 2. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI Standard 410.
  - 3. Coil casing shall be constructed of 16-gauge galvanized steel or type 201 stainless steel.
  - 4. Headers shall be copper.
  - 5. Evaporator coil shall be provided with adjustable superheat controls and external equalizers.
  - 6. Coils shall be tested to be leak-free with nitrogen at 500 PSIG under water.
  - 7. The entire refrigerant piping circuit shall be leak tested at 150 PSIG air pressure.
- B. The evaporator coil shall be provided with a drain pan which shall be fabricated of 14-gauge 201 stainless steel and sloped for positive drainage of condensate. A 1-1/4-inch diameter condensate drain connection shall be provided on both sides of the unit for slab coils.
- C. Coils shall be equal to sizes and capacities scheduled.
- D. Coils mounted in casing shall be accessible for service and shall be removable from either side of unit without dismantling entire unit.

## 2.07 GAS HEATER

- A. Construction
  - 1. The heat exchanger primary drum shall be constructed of 16-gauge formed and welded series 300 stainless steel.
  - 2. Secondary tubes shall be constructed of 14-gauge high carbon steel or series 400 stainless steel.
  - 3. The burner shall be of the power-firing type and incorporate a primary combustion air blower and spark ignition transformer.
- B. Controls
  - 1. The gas train shall be complete with all ETL-approved controls and shall be factory mounted in the unit heater vestibule.
  - 2. Standard controls include main gas valve, flame supervision, positive burner safety switch, main gas cock, and adjustable main regulator.
- C. The burner shall be factory fired and adjusted for proper combustion.
- D. Final adjustment will be made in the field during unit start-up by a factory representative.
- E. The heater shall be vented through an exhaust stack.
- F. The stack shall include a ¾-inch diameter FPT threaded condensate connection.
- G. The gas train shall be complete with all components required to meet FM code.

## 2.08 PLENUM SUPPLY FANS

- A. The FANWALL™ system, as manufactured by Huntair Inc., shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. The FANWALL™ TECHNOLOGY array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11-gauge, A60 Galvanized steel intake wall, 14-gauge spun steel inlet funnel, and an 11-gauge G90 Galvanized steel motor support plate and structure. The fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. All motors shall be standard pedestal mounted type, ODP, T-frame motors selected at the specified operating voltage, 1750 RPM, and efficiency as specified or as scheduled elsewhere. All motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.
- B. The FANWALL™ TECHNOLOGY array shall be provided with acoustical silencers that reduce the bare fan discharge sound power levels by a minimum of 15 dB re 10-12 watts throughout the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 HZ when compared to the same unit without the silencers. The silencers shall not increase the fan total static pressure, nor shall it increase the airway tunnel length of the air handling unit when compared to the same FANWALL™ TECHNOLOGY unit without the silencer array.
- C. Alternate manufacturers must submit acoustical data for review and approval prior to the bid indicating that the proposed alternate equipment can meet all specified performance requirements without impacting the equipment performance or design features including duct connection location, unit weights, acoustical performance, or specified total fan horsepower for each FANWALL™ TECHNOLOGY array.
- D. The FANWALL™ TECHNOLOGY array shall consist of multiple fan and motor "cubes," spaced in the airway tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. Three fan cubes shall be wired to a VFD as

specified elsewhere for each fan motor, driven by a "master/slave" control scheme. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.

- E. The FANWALL™ TECHNOLOGY array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit not to exceed the specified cooling coil and/or filter bank face velocity when measured at a point 12" from the intake side of the Fan Wall array intake plenum wall, and at a distance of 48" from the discharge side of the FANWALL™ TECHNOLOGY intake plenum wall.
- F. Each fan/motor assembly shall be removable through a 36" wide, free area, access door located on the discharge side of the FANWALL™ TECHNOLOGY array.
- G. Fan bearings
  - 1. Bearings shall be of the self-aligning ball bearing pillow block type and shall be designed for at least 200,000 hours average life..
  - 2. A. An engineered set of pitot tubes shall be installed in the inlet cone of the supply fan. When plumbed to a transducer (supplied and/or installed by Mammoth or others), these probes will allow for the monitoring of a particular fan's CFM.
- H. Fan inlet vanes and inlet cones: Heavy-gage steel securely attached to fan panels, with motorized operators. Use for backdraft control when only one supply fan is operating.
- I. Wheel personnel guards: Minimum 18-gage expanded metal, suitably braced with angle and bar with removable panels at top and both sides. All 3 panels shall be equipped with 2 handles for easy lifting.
- J. Provide vibration isolation of fans.
- K. Manufacturer: Mammoth, Huntair, Trane, McQuay, or equal.

#### 2.09 VARIABLE AIR VOLUME DEVICE – VARIABLE FREQUENCY DRIVE

- A. The unit shall be capable of delivering variable air volume by means of a variable frequency drive with a Mammoth two-way manual bypass switch.
- B. The unit shall include a common VFD for the Fan Wall supply air fans.
- C. The unit shall include a common VFD for the exhaust fans.
- D. Refer to the Sequence of Operation for operation of the VFDs.

#### 2.10 FILTERS

- A. The unit shall be provided with a filter rack constructed of 18-gauge galvanized steel. Filters shall be 30% efficient in accordance with ASHRAE Test Standard 51.1-92, front loaded 2- or 4-inch pleated media filters. Filter bank shall be face loaded on the entering side of the coiling coil or flat or angular. Access to the filters will be through full-size hinged access door(s).
- B. Manufacturer: Farr 30-30, or equal.

#### 2.11 SMOKE DETECTORS

- A. Smoke detectors may be mounted in the supply or return air ducts.
  - 1. The air duct smoke detector shall be a System Sensor Model DH100ACDC Series Duct Smoke Detector.
  - 2. The detector housing shall be UL listed per UL 268A specifically for use in air handling systems.
  - 3. The detector shall operate at air velocities of 500 feet per minutes to 4000 feet per minute.

4. The detector shall be capable of providing a trouble signal in the event the front cover is removed and shall be capable of local testing via magnetic switch or remote testing using the RTS451 KEY Remote Test Station.
5. Local reset button or remote test station shall reset the unit.
6. The duct detector housing shall incorporate an air-tight smoke chamber in compliance with UL 268A, Standard for Smoke Detectors for Duct Applications.
7. The housing shall be capable of mounting to either rectangular or round ducts without adapter brackets.
8. An integral filter system shall be included to reduce dust and residue effects on detector and housing, thereby reducing maintenance and servicing.
9. Sampling tubes shall either be telescoping or be easily installed by passing through the duct housing after the housing is mounted to the duct.
10. The unit shall provide a spatial separation of no less than ¼" and/or a physical barrier between the high and low voltage terminals.
11. The enclosure shall meet all applicable NEC and NFPA standards regarding electrical junction boxes.
12. Terminal connections shall be of the strip and clamp method suitable for 12-18 AWG wiring.

## 2.12 OUTSIDE AND RETURN AIR DAMPERS

- A. Outside air and return air (economizer) dampers shall be constructed of heavy gauge, aluminum airfoil-shaped blades and 14-gauge galvanized steel frames.
- B. The damper blades shall be mounted to plated square shafts which rotate in permanently-lubricated nylon bearings to insure smooth operation.
- C. Vinyl blade seals shall be locked into extruded aluminum blade slots.
- D. Side seals shall be constructed of flexible metal compression-type stainless steel.
- E. Damper blades shall operate without clatter or binding and damper linkage will be located out of the air stream.
- F. Actuator shall be direct-mounting type.
- G. A Ruskin AMS50 or IAQ50 air monitoring station shall be mounted in the upper half of one of the outside air intakes in order to maintain minimum airflow into the unit.
- H. The air monitoring station shall include outside air control damper with actuator, airflow monitoring blades, and air straightening section.
- I. The integral air monitoring station shall incorporate measuring ports built into the monitoring blades and shall control minimum outside air as required.
- J. The damper includes control damper blades made of heavy gauge, extruded aluminum airfoil-type with blade edge seals and flexible, metal, compression-type jamb seals along the damper sides. Airflow monitoring blades shall be heavy gauge, anodized, extruded aluminum airfoil-shaped fixed in a galvanized frame.
- K. Leakage rate: 1.90 cfm at 1.0" wc to 5.2 cfm per each square foot of damper area at 4.0" wc static pressure across blade surface. Actuators shall be provided by control manufacturer and mounted by penthouse manufacturer.
- L. Color and finish: See article "Color and Finish."
- M. Manufacturer: Mammoth, or equal.

### 2.13 OUTSIDE AIR LOUVERS – ECONOMIZER

- A. Outside air louvers shall be of a storm-proof design and provided with a ½-inch by ½-inch galvanized bird screen. A fully-insulated divider deck shall be provided to separate outside air from return air.

### 2.14 PROPELLER EXHAUST FANS – DIRECT DRIVE

- A. Propeller exhaust fans shall be direct-drive, propeller-type, designed for low tip speed. Motors shall be open drip-proof, three-phase, with internal motor protection and permanently-lubricated ball bearings. Each fan shall have a barometric relief damper.

### 2.15 BAROMETRIC RELIEF DAMPER ASSEMBLY – COUNTERBALANCED

- A. The economizer shall employ a barometric relief damper assembly to provide barometric relief and maintain a slight positive pressure in the return air plenum. The dampers shall utilize individual aluminum blades and shall be equipped with extruded vinyl blade seals. Counterbalance weights shall be supplied to minimize pressure loss through the dampers.

### 2.16 GENERAL ELECTRICAL

- A. All electrical wiring conforms to UL 1995. Where required, wiring will be run in EMT. Wire and conduit entrance shall be inside the unit curbing. The unit shall be equipped for single source power connection.

### 2.17 MAIN CONTROL PANEL – EXTERIOR

- A. The main control panel will have access door(s) for direct access to the controls. The panel shall be equivalent to NEMA type 3R (rainproof) and contain a single externally-operated, molded case switch (non-automatic circuit breaker) suitable for copper wire up to and including 3-inch conduit. Wire and conduit entrance will be inside the unit curbing. Low-voltage control panel wiring shall be enclosed in a wiring duct.

### 2.18 SERVICE OUTLET AND LIGHTS

- A. GFCI-type service outlet(s) shall be provided as shown on the submittal drawing(s). Power is provided from the main unit. Circuit shall remain energized regardless of main unit disconnect position.
- B. Lights not in the air stream shall be fluorescent with a wire guard. Lights in the air stream shall be vapor-proof screw-in type fluorescent or incandescent with a cast alloy base with threaded hubs, gasketed glass cover, and wire guard or fluorescent with a plastic cover. Lights shall be provided as shown on the submittal drawing(s). Lights are wired to a single switch or individual switches. Power shall be on the same circuit as the Service Outlet. Light circuit shall remain energized regardless of main unit disconnect position.

### 2.19 MAIN CONTROL PANEL COMPONENTS

- A. The control panel includes the following:
  1. A power bus bar with motor protectors and contactors
  2. Phase monitoring protection
  3. Minimum run time relay
  4. Minimum off time relay
  5. VFDs
  6. A power transformer with a primary circuit breaker (mounted on the bus bar), 115-volt secondary, and 115-volt circuit breaker
  7. 24-volt control transformer and fuse
  8. All control relays necessary for control functions
  9. A 115-volt terminal strip

10. A 24-volt control terminal strip containing wired terminals for all controls, numbered in accordance with the wiring diagram
11. An isolated 24-volt field wiring terminal strip
12. Temperature controls

- B. The above components shall be in addition to electrical components associated with other sections which shall be incorporated in the main control panel to facilitate maintenance and trouble shooting.

## 2.20 ROOF CURB

- A. The roof curb shall be prefabricated from 12-gauge galvanized steel and shall be a minimum of 24 inches high. The curb shall be a full-perimeter type and shall include 14-gauge galvanized steel pan type cross bracing to maintain squareness and rigidity. Curb gasket shall be provided to form a positive seal between the unit mounting frame and curb top perimeter. Unit base frame shall overlap curb to provide a positive weatherproof seal. Curb shall be custom designed and built to match the pitch of the existing roof.
- B. Curb nailer
  1. The curb shall include a nominal 2-by-4-inch wooden nailer strip for attachment of roofing materials.
- C. Roof curb insulation
  1. Roof curb insulation is 4 inch thick, 3-pound density fiberglass and shall be shipped loose for field installation to curb exterior. Attachment clips are included.

## PART 3 EXECUTION

### 3.01 FIELD STARTUP

- A. Field erect under supervision of factory-designated representative.
- B. Installation shall be as recommended by manufacturer with all joints between sections, airtight and watertight. Touch-up damaged paint and repair damaged panels after installation is complete.
- C. Manufacturer shall be responsible for commissioning mechanical penthouse, fans, coils, compressors, motorized dampers, etc.
- D. Manufacturer's representative to provide start up report including status and range of conditions of all operating components. Include sound test data.
- E. Manufacturer's representative shall demonstrate to owner all aspects of all operating components.
- F. Manufacturer's representative shall provide training of owners' maintenance staff.

END OF SECTION

- 1) D. Rollins
- 2) S. Primrose

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. Fan-coil units.

### 1.02 RELATED SECTIONS

- A. Section 20 05 00 – Common Work Results for Facilities Systems Services
- B. Section 26 05 00 – Common Work Results for Electrical
- C. Section 26 05 63 – Small Single Phase Motors.
- D. Section 26 05 66 – Small and Medium 3-Phase Motors

### 1.03 REFERENCES

- A. Materials and workmanship shall conform to the latest issue of all industry standards, publications, or regulations referenced in this section and with the following references as applicable. Refer to Section 20 05 00 for listing of issuing organizations or agencies.
  - 1. NFPA 70 - National Electrical Code.

### 1.04 SUBMITTALS

- A. Submittals For Review
  - 1. Product Data: Provide typical catalog of information including arrangements.
  - 2. Shop Drawings:
    - a. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
    - b. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
    - c. Indicate mechanical and electrical service locations and requirements.
- B. Submittals At Project Closeout
  - 1. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
  - 2. Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
  - 3. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

### 1.05 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc. (or other testing agency acceptable to the authority having jurisdiction) as suitable for the purpose specified and indicated.

### 1.06 WARRANTY

- A. Provide five year manufacturers warranty for fan-coil unit.

### 1.07 EXTRA MATERIALS

- A. Provide two sets of filters.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS - FAN COIL UNITS

- A. Manufacturers:
  - 1. Trane Co.
  - 2. Enviro-Tec
  - 3. York

### 2.02 FAN-COIL UNITS

- A. Horizontal air handling unit and mixing box with hydronic coils, drain pan, and centrifugal fan with motor and drive mounted in a common cabinet. Drive location and coil connections are independent for the same or opposite side location.
- B. Chilled Water Cooling Coils: Seamless copper tube aluminum fin assembly, galvanized, polymer, or stainless steel and insulated drain pan, drain connection.
- C. Cabinet: 0.0598 inch steel with exposed corners and edges rounded, easily removed panels, insulated with one inch, 1 ½ lb density fiberglass fire resistant and odorless glass fiber material to provide thermal and acoustical insulation.
- D. Finish: Factory apply baked enamel of color as selected by Project Manager on visible surfaces of enclosure or cabinet.
- E. Fans: forward curved, centrifugal blower type equipped with heavy-duty adjustable speed V-belt drive. Fan shaft supported by heavy-duty, permanently sealed ball bearings. Statically and dynamically balanced fan.
- F. Motor: Single speed, open drip-proof with permanently sealed ball bearings, internal overload protection, and minimum 1.15 service factor, resiliently mounted.
- G. Control: Multiple speed switch, factory wired, located in cabinet, with access door for switch and control valves.
- H. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.
- I. Electrical Characteristics: As indicated on the drawings.

### 2.03 SUPPLEMENTAL CONDENSATE DRAIN PANS

- A. Wherever units equipped for cooling service are installed above facilities such as electrical power equipment, computer equipment, data server or telecommunications equipment, or other electrical or electronic equipment susceptible to malfunction if exposed to water, Contractor shall provide a supplemental drain pan to serve as additional protection against leakage, overflow, or other failure of the primary drain pan normally comprising a part of the air conditioning equipment.
  - 1. Supplemental drain pans to be constructed of 20 gauge (minimum) galvanized steel, minimum depth 2 inches, fabricated, insulated, braced, and supported so as to ensure stability.
  - 2. Provide drain piping, as applicable, minimum size 3/4 inch, terminating as a visible sight drain discharging to a floor drain or service sink if feasible, or as may otherwise be directed or approved by the DIA Project Manager.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install equipment exposed to finished areas after walls and ceiling are finished and painted. Avoid damage.
- C. Protection: Provide finished cabinet units with protective covers during balance of construction.
- D. Fan-Coil Units: Install as indicated. Coordinate to assure correct recess size for recessed units.
- E. Units with Cooling Coils: Connect drain pan to condensate drain.

### 3.02 CLEANING

- A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- C. Install new filters.

**END OF SECTION**

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Hot water coils.
- B. Chilled water coils.

1.02 INFORMATIONAL SUBMITTALS

- A. Product Data:
  - 1. Data concerning dimensions, capacities, materials of construction, ratings, weights, and appropriate identification.
  - 2. Manufacturer's installation instructions.
  - 3. Manufacturer's descriptive literature, operating instructions, and maintenance and repair data.

1.03 QUALITY ASSURANCE

- A. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI Standard 410.

**PART 2 PRODUCTS**

2.01 HOT WATER COILS

- A. Characteristics:
  - 1. Copper tubing 1/2" O.D. minimum.
  - 2. Suitable for working pressure of 200 psig, and 250°F.
  - 3. Mechanically expanded into aluminum fins.
- B. Coil fins: Continuous-serpentine or plate-fin type.
- C. Headers:
  - 1. Cast iron with tubes expanded into headers.
  - 2. Steel pipe with brazed connections, or
  - 3. Heavy seamless copper with tubes brazed to header.
- D. Casing:
  - 1. Galvanized steel end supports, rigid top and bottom channels.
  - 2. Allow for expansion and contraction of finned tubes.
- E. Turbulators: Use where needed to provide scheduled capacity.

2.02 CHILLED WATER COILS

- A. Characteristics:
  - 1. Copper tubing, 1/2" O.D. minimum.
  - 2. Suitable for working pressures up to 200 psig.
  - 3. Aluminum fins.
- B. Coil fins: Continuous plate fin type.
- C. Headers:
  - 1. Cast iron with tubes expanded into headers,
  - 2. Steel pipe with brazed tube connections, or
  - 3. Heavy seamless copper with all tubes brazed to header.

- D. Casing:
  - 1. Galvanized steel and supports, rigid top and bottom channels.
  - 2. Allow for expansion and contraction of finned tube section.
- E. Coils: Cleanable-type with removable, gasketed headers for complete access for mechanical cleaning.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. Support coil sections on steel channel or double-angle frames and secure to casing.
- B. Arrange supports for cooling coils to avoid piercing or short-circuiting drip pans.
- C. Bolt casings to other section, ductwork, or unit casings.
- D. Install airtight seal between coil and duct or unit cabinets.
- E. Make connections to coils, including valves, air vents, unions, and connections from drip pans.
- F. Install isolation valve on supply line and balancing valve on return line from each water coil.
- G. Install vacuum breaker in steam line at header, or in header.
- H. Protect coils so fins and flanges are not damaged.
- I. Replace loose or damaged fins.
- J. Comb out bent fins.
- K. Level serpentine coils and install cleanable tube coils and steam coils with 1:50 pitch.
- L. Install piping flexible connections and/or piping vibration isolation supports as specified in Section 20 05 48.
- M. Cooling coils: Pipe condensate pan to nearest drain with trap.

END OF SECTION

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. General electrical requirements for equipment and services including, but not limited to:
  - 1. Factory wiring.
  - 2. Low voltage field wiring.
  - 3. Low voltage splices and terminations.
  - 4. Low voltage cabinets and electrical enclosures.
  - 5. Equipment safety grounding.
  - 6. Low voltage fuses and fuse blocks.
  - 7. Electrical meters.
  - 8. Control relays and switches.
  - 9. Pushbuttons.
  - 10. Indicating lights.
  - 11. Alarm and trip contacts.
  - 12. Low voltage starters.
  - 13. Low voltage circuit breakers and disconnect switches.
  - 14. Auxiliary power transformers.
  - 15. Power factor correction capacitors.
  - 16. Outlet, pull, and junction boxes.
  - 17. Plates and covers.
  - 18. Wiring devices.
  - 19. Welding receptacles.
  - 20. Panelboards.
  - 21. Welding.
  - 22. Shop finish.
  - 23. Rust-inhibiting compounds.
  - 24. Galvanizing.
  - 25. Packaging, identification, and tagging.
  - 26. Nameplates.
  - 27. Trip setting coordination.
  - 28. Grounding and bonding.
  - 29. Fireproofing and fire ratings.
  - 30. Testing and demonstration.

### 1.02 RELATED REQUIREMENTS

- A. Section 02 41 00 –Demolition: Demolition of electrical items.

### 1.03 INFORMATIONALSUBMITTALS

- A. Submit with Bid: Description of manufacturer's standard factory test procedure for logic systems.
- B. Product Data:
  - 1. List of proposed material identifying manufacturer, type and model number for equipment to be provided for complete job.
  - 2. Manufacturer's catalog sheets marked to indicate specific type, model or catalog number of equipment to be provided.
  - 3. Equipment drawings, elementary diagrams, schematics, wiring, performance curves, instruction manuals, and all other documentation necessary for complete description of material being supplied and as required to support installation, commissioning and maintenance of equipment. Manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted.
  - 4. Manufacturer's technical descriptions, product data sheets, and applicable manuals for use in protective device system coordination including:

- a. Fuse manufacturer, type, ratings, and protection curves.
  - b. Circuit breaker manufacturer, type, trip setting ranges, and protection curves.
  - c. Relay trip device ranges, curves, and setting manuals.
  - d. Transformer damage curves.
  - e. CT ratios and saturation curves.
  - f. VT ratings.
5. List of recommended spare parts required for equipment start-up, commissioning and operation.
  6. List of special maintenance tools required for installation and operation of equipment.
  7. If necessary, provide additional data to clearly demonstrate that proposed alternate equipment meets or exceeds equipment as specified.
  8. When requested by Engineer, submit system information, including but not limited to, utility feeders, existing relays, circuit breakers, fuses, and transformers.

#### 1.04 CLOSEOUT SUBMITTALS

- A. Operation and maintenance manuals. Provide at minimum:
  1. Itemized equipment list.
  2. General description and technical data.
  3. Receiving, storage, installation, and testing instructions.
  4. Operating and maintenance procedures.
  5. Complete set of final drawings requiring no further action.
  6. Complete documentation of inspections and tests performed, including logs, curves, and certificates. Documentation shall note any replacement of equipment or components that failed during testing.
  7. Spare parts list.
  8. Lubrication recommendations.
  9. Warranty information.

#### 1.05 MAINTENANCE MATERIALS

- A. Extra materials: Provide touchup paint in same type and color to repair at least 25% of finish-painted equipment surface. Paint shall be sufficient to perform touch-up painting in accordance with shop-applied material instructions for repair painting.
- B. Each piece of equipment shall be furnished with special tools as required for installation, maintenance, and dismantling of equipment.
  1. Furnish in quantities as necessary to complete work on schedule.
  2. Tools shall be new and shall become property of Owner.
  3. Tools and intended use shall be identified in assembly instructions. Tools shall only be used for their intended purpose.

#### 1.06 QUALITY ASSURANCE

- A. Manufacturer qualifications:
  1. Manufacturer of equipment specified shall be recognized in industry for normally supplying this type of equipment.
  2. Manufacturer shall be ISO certified.
  3. When requested by Engineer, provide list of similar equipment installations that have employed identical equipment from manufacturer.
- B. Installer qualifications:
  1. Installer shall be skilled in trade and shall have thorough knowledge of products and equipment specified.
  2. Cutting, drilling, trenching, or channeling necessary to properly install equipment shall be performed by competent skilled crafts people in safe, professional manner.

- C. Regulatory requirements: Perform electrical construction in accordance with NEC, local and state codes as applicable to job site.
- D. Materials and equipment furnished for permanent installation shall be new, unused, and undamaged.
- E. Asbestos not allowed.
- F. Parts shall be manufactured to American industry standard sizes and gages to facilitate maintenance and interchangeability. Metric sized components not allowed unless specifically requested and approved.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Pack, ship, handle, and store in accordance with manufacturer's requirements.
- B. Ship equipment completely factory assembled unless physical size, arrangement, configuration, or shipping and handling limitations make this impracticable. Shipping splits and required field assembly shall be identified with equipment submittals.
- C. Costs associated with sections, accessories, or appurtenances requiring field assembly shall be Contractor's responsibility.
- D. Separately packaged parts and accessories shall be consolidated and shipped together with equipment. Mark each container clearly to identify contents and as belonging with main equipment.
  - 1. Provide individual weatherproof itemized packing slips attached to outside of each container for contents included. Provide duplicate inside each container.
  - 2. Attach master packing list, covering accessory items for equipment, to main piece of equipment.
  - 3. Mark each container with project identification number for equipment and container number followed by total number of containers.
- E. Equipment shall be suitably protected during shipment, handling, and storage. Damage incurred during shipment shall be repaired at not cost to Owner.
- F. Protect coated surfaces against impact, abrasion, and discoloration.
- G. Electrical equipment and insulation systems shall be protected against ingress of moisture. Use space heaters if necessary to protect against moisture.
- H. Exposed threads shall be greased and protected.
- I. Pipe, tube, and conduit connections shall be closed with rough usage plugs. Seal and tape open ends of piping, tubing, and conduit.
- J. Equipment openings shall have covers, and taped to seal equipment.
- K. Store materials in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

#### 1.08 SCHEDULING

- A. Coordinate with Owner early and late shipping and delivery schedules for items requiring storage and handling at Site.

#### 1.09 WARRANTY

- A. Electrical equipment shall be provided with manufacturer's standard warranty, but not less than 1 year.

**PART 2 PRODUCTS****2.01 DESIGN CRITERIA**

- A. Service conditions: Provide equipment and material suitable for intended service and installation at location indicated.
- B. Low-voltage auxiliary and control power.
1. Electrical power for ac control and instrumentation equipment:
    - a. Provide devices necessary for proper operation and protection of equipment during electrical power supply and ambient temperature fluctuations specified.
    - b. Design for continuous operation at any voltage from 85% to 110% of nominal voltage. Dropout voltage shall be 60% of nominal for relays and 75% for contactors and starters.
  2. Electrical power for dc devices:
    - a. Design for continuous operation on ungrounded station battery system, capable of maintaining operation at any voltage from 80% to 112% of nominal voltage.
    - b. Electrical devices served shall not impose ground connection on supply.
- C. Auxiliary power: Design auxiliary equipment for low voltage service, with electrical power designed to operate from one of nominal electrical power sources as follows and as indicated on Drawings:

Volts	Phase	Frequency
480Y/277	3 or 1	60
208Y/120	3 or 1	60

**2.02 FACTORY WIRING**

- A. Select cable for electrical and environmental conditions of installation, and suitable for unusual service conditions where encountered.
1. Proper temperature application cable shall be used throughout, but shall be not less than 90°C rated.
  2. Conductors routed over hinges shall use extra-flexible stranding.
  3. Cable insulation shall be rated for maximum service voltage used, but not less than 600 volts.
  4. Splices not allowed.
- B. Panel, control cabinet, switchboard, motor control center, and switchgear wiring shall use flame retardant cross-linked polyethylene (XLP) or flame retardant ethylene-propylene rubber (EPR) insulation that meet or exceed requirements of UL 44 for Types SIS, and XHHW.
1. Minimum size: No. 14 AWG (1.5 mm<sup>2</sup>).
  2. Conductors: Annealed bare copper Class B stranding passing IEEE 1202 and UL VW-1 flame test.
- C. Instrumentation, thermocouple, and thermocouple extension wire shall use twisted shielded pairs/triads having flame retardant cross-linked polyethylene (XLPE) insulation, and chlorinated polyethylene (CPE) jacket.
1. Minimum size: No. 16 AWG (1.0 mm<sup>2</sup>).
  2. Conductor type:
    - a. Instrument: Annealed copper Class B stranding.
    - b. Thermocouple: Solid alloy, ANSI MC 96.1.
  3. Provide each pair/triad with shield.
  4. Shielding shall consist of aluminum-polyester tape and flexible strand tin-coated No.18 AWG (0.75 mm<sup>2</sup>) copper drain wire.
  5. Drain wire for each instrument cable shall be insulated with spaghetti sleeve. One end of shield wire shall be terminated on grounded terminal.
  6. Cables shall pass IEEE 1202 and ICEA 70,000 Btu/Hr vertical tray flame test, and each conductor shall pass UL VW-1 flame test.

## D. Terminations:

1. Conductor terminal connectors shall be insulated, ring tongue, compression type connectors properly sized for conductor and terminal.
  - a. Connectors shall be constructed of copper and shall be tin-plated.
  - b. Interior surface of connector wire barrel shall be serrated; exterior surface of connector wire barrel shall be furnished with crimp guides.
2. Noninsulated terminal connectors shall be used for conductors terminated on devices equipped with individual fitted covers, such as, but not limited to, control switches and lockout relays.
3. Connections requiring disconnect plug and receptacle type devices shall be provided with factory-terminated conductors on each plug and receptacle.
  - a. Plugs and receptacles shall be factory wired into junction boxes containing terminal blocks for external connections.
  - b. Conductors on disconnect portion of plug-receptacle assemblies shall be in common jacket.
4. Prior to shipment of equipment, remove temporary wiring installed in factory for equipment testing.
5. Current transformers shall terminate on shorting type terminal blocks. Ship with shorting jumpers installed.

## E. Identification and labeling:

1. Provide conductor identification sleeve on each end of each internal conductor. Mark each sleeve with opposite end destination identification with nonsmudging, permanent black ink. Sleeves shall be UV-resistant self-adhesive type or PVC, not less than 1/2" long.
2. Permanently label each terminal block, terminal, conductor, relay, breaker, fuse block, and other auxiliary devices to coincide with identification indicated on manufacturer's drawings.

## 2.03 FIELD WIRING

## A. Nationally or internationally recognized cable manufacturer shall produce cable provided.

1. Metal-clad cable, NEC Type MC, may not be substituted in place of cable and conduit unless specified otherwise, or unless approved in writing.
2. Comply with code and Project requirements directly associated with use of each cable type.

## B. Cables specified are for voltages 600 volts and below.

## C. Wiring shall be bare copper with not less than 98% conductivity, unless specified otherwise.

## D. General-purpose building conductor used on interior lighting circuits and general-purpose branch circuits routed entirely in conduit shall be single conductor.

1. Voltage rating: 600-volt.
2. Conductor: Class B, solid or stranded, annealed, uncoated copper, minimum size No. 12 AWG (4.0mm<sup>2</sup>).
3. Insulation: PVC complying with physical and electrical requirements of UL for type THHN/THWN.
4. Jacket: Overall clear nylon jacket applied over conductor insulation, UL-listed as gasoline and oil resistant.
5. Provide conductor sizes No. 8 AWG and smaller in colors to match wire color-codes. Sizes No. 6 AWG and larger shall be color-coded with field-applied tape.
6. Rated continuous operating temperature shall be 90°C in wet and dry locations for operation at maximum 75°C.

## E. Single-conductor, low-voltage power cable for motors, feeders, branch circuits, and dc circuits routed in conduit, duct bank, or cable tray:

1. Voltage rating: 600-volt.
2. Conductor: Annealed, bare copper, Class B, stranded, minimum size No. 12 AWG (4.0mm<sup>2</sup>).
3. Insulation: Ethylene propylene rubber (EPR), complying with physical and electrical requirements for NEC Type RHH or RHW-2.
4. Jacket: Flame-retardant, heat, moisture, and sunlight resistant; cross-linked low-smoke, nonhalogen polyolefin (XLPO).

5. Conductor sizes No. 8 AWG and smaller shall be provided in colors to match wire color-codes. Sizes No. 6 AWG and larger may be color-coded with field applied tape.
  6. Wire shall be identified by surface marking indicating manufacturer, conductor size, conductor material, voltage rating, UL symbol, and listed type.
  7. Cables smaller than No. 1/0 AWG (50 mm<sup>2</sup>) shall be routed entirely in conduit and duct bank in. Sizes No. 1/0 AWG (50 mm<sup>2</sup>) and larger may be routed in cable tray, if so rated.
  8. Conductors shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and UL VW-1 vertical flame test.
  9. Temperature rating shall be 90° C for normal operation in wet or dry locations.
- F. Multiconductor, low-voltage power cables for motors, feeders, and branch circuits routed in cable tray, conduit or duct bank:
1. Voltage rating: 600-volt.
  2. Conductors: Annealed, bare copper, Class B, stranded, minimum size No. 12 AWG (4.0mm<sup>2</sup>).
  3. Insulation: Flame-retardant, cross-linked polyethylene (XLPE) or cross-linked polyolefin (XLPO), complying with physical and electrical requirements for NEC Type XHHW-2.
  4. Jacket: Flame-retardant, heat, moisture, and sunlight-resistant; cross-linked, low-smoke, nonhalogen polyolefin (XLPO).
  5. Phase conductors shall be cabled together with Class B stranded, uncoated copper grounding conductor and fillers. Ground wire size shall comply with requirements of UL 1277.
  6. Cover cable assembly with helically applied polyester binder tape with minimum 10% overlap.
  7. Marking: Insulated phase conductors shall be black and shall have printed numbers in accordance with ICEA Method 4. Each cable shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, metal, voltage rating, and UL listing as suitable for cable tray use.
  8. Cables shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and individual conductors UL VW-1 vertical flame test.
  9. Conductors shall be temperature rated for 90° C maximum continuous operating temperature in wet or dry locations.
- G. Multiconductor, low-voltage power cables for motors fed from adjustable speed drives, any installation.
1. Voltage rating: 600-volt.
  2. Conductors: Annealed, bare copper, Class B, stranded, minimum size No. 10 AWG (4.0mm<sup>2</sup>)
  3. Insulation: Flame-retardant, cross-linked polyethylene (XLPE) complying with physical and electrical requirements for NEC Type XHHW-2.
  4. Jacket: Flame-retardant, polyvinyl chloride (PVC).
  5. Armor/shield: Continuously welded and corrugated high conductivity aluminum.
  6. Ground conductors: 3 segmented Class B strand, annealed copper conductors sized to meet requirements of UL 1569.
  7. Marking: Insulated phase conductors shall be black and shall have printed numbers in accordance with ICEA Method 4. Each cable shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, metal, voltage rating, and UL listing.
  8. Cables shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and individual conductors UL-approved and marked with FT-4 designation.
  9. Rated for Class 1, Div 1 hazardous locations.
  10. Conductors shall be temperature rated for 90° C maximum continuous operating temperature in wet or dry locations.
- H. Multiconductor cable for control, interlocks, current transformers (CTs), voltage transformers (VTs), meters, and relays routed in cable tray and conduit:
1. Voltage rating: 600-volt.
  2. Sizes:
    - a. Motor control, switchgear and breaker control, interlock control, metering, relaying, and general power control circuits shall be minimum size No. 14 AWG (1.5 mm<sup>2</sup>).
    - b. CT and VT circuits shall be minimum No. 10 AWG (4.0 mm<sup>2</sup>).
  3. Conductors: Annealed, bare copper, Class B, stranded.

4. Insulation: Flame-retardant, cross-linked polyethylene (XLPE) or cross-linked polyolefin (XLPO), complying with physical and electrical requirements for NEC Type XHHW-2.
  5. Jacket: Flame-retardant, heat, moisture, and sunlight resistant; cross-linked, low-smoke, nonhalogen polyolefin (XLPO).
  6. Conductors shall be cabled together with nonhygroscopic fillers.
  7. Cover cable assembly with helically applied binding tape with minimum 10% overlap.
  8. Marking:
    - a. Insulated conductors shall have colored insulation meeting ICEA Method 1, Table 2 color code to identify conductors.
    - b. Each cable shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, voltage rating, and UL listing as rated for cable tray.
  9. Cables shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and individual conductors UL VW-1 vertical flame test.
  10. Temperature rating shall be 90°C maximum continuous operating temperature in wet or dry locations.
- I. Instrumentation cable installed indoor or outdoor routed in cable tray, conduit, and ducts:
1. Voltage rating: 600-volt.
  2. Conductors: Annealed, bare copper, Class B, stranded, minimum size No. 16 AWG (1.0 mm<sup>2</sup>).
  3. Insulation: Flame-retardant, cross-linked polyethylene (XLPE) or cross-linked polyolefin (XLPO).
  4. Jacket: Flame-retardant, heat, moisture, and sunlight resistant; cross-linked, low-smoke, nonhalogen polyolefin (XLPO).
  5. Pairs/triads: Each twisted with lay not exceeding 2" (50 mm).
  6. Color code: Pairs black/white, Triads black/white/red.
  7. Assembly:
    - a. Each pair or triad shall be cabled together with aluminum/polyester tape shield helically wrapped with minimum lap of 15% of tape width and isolation tape. Entire cable assembly shall have overall aluminum/polyester tape shield helically wrapped.
    - b. Flexible strand tin-coated No.18 AWG (0.75 mm<sup>2</sup>) copper drain wire shall be helically wound between twisted conductors and tape shield.
  8. Each instrumentation cable shall be identified by means of surface ink printing indicating manufacturer, conductor size, and quantity, UL listing.
  9. Cables shall pass IEEE 1202 70,000 Btu/hr, and ICEA T-29-520, 210,000 Btu/hr vertical tray flame tests, and individual conductors UL VW-1 vertical flame test.
  10. Temperature rating shall be 90°C maximum continuous operating temperature in wet or dry locations.

## 2.04 SPLICES AND TERMINATIONS

- A. Splices, except as in lighting and general purpose power circuits specified below, not allowed unless specifically indicated on Drawings or required for connection to equipment.
- B. Temperature rating of splices and terminations shall be rated no less than 75°C.
- C. Splices allowed in lighting and general-purpose power circuits.
  1. Provide wire and cable connectors of high-conductivity, corrosion-resistant material with contact area equal to at least current carrying capacity of wire or cable.
  2. General lighting and general-purpose building power circuits:
    - a. Twist-type, insulated spring connectors for splices on solid or stranded conductors smaller than No. 6 AWG.
    - b. Use indent, hex screw, or bolt clamp-type connectors, with or without tongue for splices on solid or stranded conductors No. 6 AWG and larger.
    - c. Apply insulating 600-volt tape.
- D. Insulating tapes and compounds for terminations and splices shall be UL-listed for intended use, location, and voltage by manufacturer.

- E. Termination of conductors to equipment with bolted connections:
  - 1. Use compression type lugs:
  - 2. Compression lugs for cables 250 kcmil and larger shall have at least 2 clamping elements of compression indents, and provision for at least 2 bolts for joining to apparatus terminals.
  - 3. Crimping hand tools used for securing conductors in compression type connectors or terminal lugs shall be made for purpose and conductor sizes involved.
  - 4. Crimping tools shall be ratchet-type preventing tool from opening until crimp action is completed.
  - 5. Tools shall be product approved by connector manufacturer.
  
- F. Terminals:
  - 1. Conductors No. 10 AWG and smaller: Marathon 1500 Series.
  - 2. Conductors larger than No. 4/0 AWG: Terminate to tinned copper bus bar drilled and tapped with standard NEMA sized and spaced holes.
  
- G. Coordinate sizes and types of conductor terminals for 600-volt power cable terminations in equipment with furnished conductor and terminal connector data.
  
- H. Provide 600-volt rated terminal blocks for instrumentation and control conductors for connection to circuits external to specified equipment, and for internal circuits crossing shipping splits.
  - 1. Use crimp-on terminals matching termination point terminations in manufacturer-furnished panels. Splices not allowed.
  - 2. Terminal blocks for thermocouple extension wire: Buchanan "Medium Duty" with thermocouple contacts or Marathon 200 Series with Omega Engineering, Inc. Type TL terminal lugs.
  - 3. Furnish with white marking strips.
  - 4. Where permitted by safety codes and standards, provide without covers. Neither step-type terminal blocks nor angle mounting of terminal blocks allowed.
  - 5. Fuses may be mounted on terminal blocks.
  - 6. Maximum 2 conductors in accordance with termination point.
  
- I. Terminal blocks for external connections shall leave from centrally mounted location, not from individual devices in enclosure.
  - 1. Group-in instrument and control compartment for easy accessibility.
  - 2. Provide sufficient space on each side of each terminal block to allow orderly arrangement of leads to be terminated on block.
  - 3. Locate auxiliary equipment in compartments, enclosures, or junction boxes so service personnel will have direct access without interference from structural members and instruments without removal of barriers, cover plates, or wiring.
  - 4. Do not mount terminal blocks in compartments containing cables or buses operating at voltages above 600 volts.
  - 5. Size for wire sizes of incoming conductors as necessary.
  
- J. Install shorting-type terminal blocks nearest current transformer in accessible location for each set of CTs supplied with equipment furnished, no other shorting-type terminal blocks allowed, unless specified otherwise.
  
- K. Install din-rail mounted miniature circuit breakers (MCB) for protection of VT circuits on line and load side. Breakers shall have alarm contacts wired to terminal blocks.
  
- L. Terminate each conductor in multiconductor control cable or as shown on Drawings. Provide 10% spare terminals for circuit modifications.
  
- M. Each control switch and lockout relay shall have minimum of 4 spare normally open and 4 spare normally closed contacts wired out to terminal blocks.
  
- N. Circuit identification number listed on either circuit schedule or panel schedule shall be used to identify circuit, positioned as near as possible to end of each conductor on multiple single wire circuits and on cable jacket for multiconductor cables.

- O. Cable designations shall be visible after installation without requiring physical movement of cable.

## 2.05 ELECTRICAL ENCLOSURES

- A. Size junction boxes, pull boxes, and enclosures in accordance with requirements of NEC.
- B. Junction boxes and pull boxes 4" (100 mm) trade size or smaller in any dimension shall be galvanized malleable iron, or cast ferrous metal NEMA rated for installed location. Do not use concentric knockouts.
- C. Junction boxes, pull boxes, and electrical enclosures larger than 4" (100 mm) trade size in any dimension shall be as follows, unless required otherwise.
  - 1. NEMA rating for electrical enclosures installed in nonhazardous locations:
    - a. Indoor:
      - 1) Dry environmentally controlled area: NEMA 12.
      - 2) Noncorrosive wet or hose-down area: NEMA 4.
      - 3) Corrosive wet or hose-down area: NEMA 4X
    - b. Outdoor:
      - 1) Corrosive area: NEMA 4X.
      - 2) Noncorrosive area hose-down or spray area: NEMA 4.
      - 3) Noncorrosive area nonhose-down area NEMA 3R.
  - 2. Construct noncast-metal electrical enclosures from reinforced steel plate capable of supporting devices mounted on or within enclosure without deflection. Steel plate thickness shall conform to UL requirements.
  - 3. Enclosures shall be of adequate strength to support mounted components during shipment and installation.
  - 4. Conduit entrances shall be field drilled.
  - 5. Electrical enclosures located in outdoor, wet, or hose down areas shall be provided with space heaters. Provide space heaters completely wired within enclosure. Provide following:
    - a. Space heater.
    - b. Adjustable thermostat with set point temperature indicator.
    - c. One miniature circuit breaker protective device.
    - d. Space heaters, thermostat, and protection shall not interfere with cable into or out of enclosure, or with maintenance or replacement of devices within enclosure.
    - e. Use of space heaters shall not change or discolor any painted surface.
    - f. Space heater capacity shall maintain enclosure internal temperature above dew point under specified service conditions.
    - g. Space heaters shall be rated for 240 volts ac minimum, and shall be sized for operation on applied voltage of 120 volts ac.
- D. Outdoor electrical enclosures with ventilating openings:
  - 1. Louver on outdoor electrical equipment and protect in accordance with NEMA type.
  - 2. Equip openings on outdoor electrical equipment with fine mesh filters and stainless steel bug screens.

## 2.06 OUTLET BOXES

- A. Outlet boxes for concealed wiring systems shall be sheet metal, galvanized or cadmium plated.
- B. Boxes shall be minimum 4" (100 mm) square, 1-1/2" (38 mm) deep, sized to accommodate devices and number of conductors in accordance with NEC. Equip with plaster ring or cover as necessary for flush finish.
- C. Exposed conduit systems shall have surface-mounted boxes unless specified otherwise. Boxes for exposed wiring in nonhazardous, noncorrosive, and nonweatherproof locations shall be malleable iron, cadmium finish or cast aluminum alloy, minimum 4" (100 mm) square, 1-1/2" (38 mm) deep.

- D. Enclosures shall be as required for areas in which they are installed and as specified.
1. Boxes shall be installed flush in masonry construction and be designed for intended use.
  2. Recessed boxes where fixture will be mounted shall be minimum 4" (100 mm) and octagonal in shape or 4" (100 mm) square by 1-1/2" (38 mm) deep with round plaster ring. Where used as junction box, boxes shall be minimum 4" (100 mm) square by 2-1/8" (53 mm) deep.
  3. Outlet boxes for wall concealed telephone and signaling systems shall be 4" (100 mm) square by 1-1/2" (38 mm) deep, minimum. Furnish with plaster ring and cover plate.
  4. Floor boxes for floor outlets shall be cast-metal with threaded conduit entrances, brass flange ring and brass duplex flap cover plate. Boxes shall be watertight and have leveling and adjustment screws for adjusting cover plate to finished floor. Boxes shall be minimum 4" (100 mm) diameter and 3-1/2" (88 mm) deep with approved gasket or seal between adjusting ring and box.
  5. Floor outlets for combination signaling, data, and power outlets shall be constructed of steel base, PVC housing, and steel bracket to allow feed through wiring as well as activation load-bearing support. Box construction shall meet UL 514A requirements.
    - a. Entire housing shall be removable for unrestricted access.
    - b. Once assembled, PVC housing shall be capable of carrying 6,000 lb (2722 kg) load.
    - c. Coordinate outlet requirements with communication system requirements.
  6. Floor boxes in 2-hour rated floors shall be secured in cored hole and shall be UL classified and listed for 2-hour rated floors.

## 2.07 PULL AND JUNCTION BOXES

- A. Furnish junction boxes and pull boxes were shown on Drawings, and where necessary to facilitate pulling wires and cables without damage.
- B. Above ground boxes shall be formed from sheet steel, with corners folded in and securely welded with inward flange on each of 4 edges.
- C. Drill box for mounting and attachment of cover; galvanize after fabrication.
- D. Cover shall be made of one-piece galvanized steel and provided with stainless steel round head machine screws.
- E. Box and cover shall be made of code gage steel, or heavier if shown on Drawings.
- F. Boxes shall be minimum 4-1/2" (113 mm) deep. Size shall be in accordance with NEC. Use next larger standard size when necessary in accordance with manufacturer standard sizes.
- G. Pull and junction boxes shall be furnished without knockouts for field drilling.
- H. Enclosures shall be as required for areas in which installed and in accordance with requirements specified.
- I. Underground boxes shall be specifically designed and constructed for intended installed location, and shall be either pre-formed concrete or PVC. Covers shall be capable of withstanding, without failure, type of traffic in general area.
- J. If pull and junction boxes are exposed in and around architecturally finished surfaces, paint box to match finish of nearby surfaces, unless indicated otherwise.
- K. Bolt-on junction box covers 3'-0" (900 mm) square or larger, or heavier than 25 lb. (11 kg) shall have permanent rigid handles. Covers larger than 3'-0" x 4'-0" (900 mm x 1200 mm) shall be split.

## 2.08 EQUIPMENT SAFETY GROUNDING

- A. Install exposed raceway electrically continuous. Conduit and tray shall not be considered to be only ground conductor.

- B. Furnish equipment that is part of integral shipping unit or assembly with bare copper ground conductor extending to central ground connection lug. Lug shall be suitable for field connection to local ground. Electrical equipment shall be considered any device that is energized.
- C. Single-point ground connections required for proper operation of electronic equipment shall be insulated from equipment safety ground. Such connections shall be extended, using insulated cable, to single insulated termination point suitable for field connection to appropriate ground system.
- D. Conduits that contain power circuits shall have ground conductor installed inside conduit. Ground conductor shall be bonded to equipment or tray or duct ground at both ends.
- E. Provide ground bushing on each conduit containing power circuit. Connect ground bushings together inside enclosure and to enclosure ground lug or ground bus.
  - 1. Use No. 8 AWG conductor for ground bushings trade size 1-1/2" (38 mm) and smaller.
  - 2. Ground bushings larger than 1-1/2" (38 mm) shall be sized in accordance with requirements of NEC, but in no case shall they be smaller than No. 8 AWG.
- F. Ground conductor: Uninsulated, Class B standard, round soft drawn uncoated copper as defined in ICEA S-19-81, unless specified otherwise.
- G. Hardware: Clamps, bolts, washers, nuts, and other hardware used with grounding conductor shall be copper, copper alloy, high copper alloy, or silicon bronze.

#### 2.09 PIN AND SOCKET CONNECTORS

- A. Unless shown on Drawings, not allowed.

#### 2.10 FUSES AND FUSE BLOCKS

- A. Modular-type, Class H screw terminal fuse blocks with Bakelite frame and reinforced retaining clips. Blocks shall be similar in construction and by same manufacturer.
- B. Slow blow fuses: Bussmann Type MDL or Gould Shawmut Type GDL with ampere ratings of 1/4, 1/2, 1, or 2.
- C. Fast acting fuses: Bussmann Type NON or Gould Shawmut Type OT with ampere ratings of 1, 3, 6, 10, 15, 20, or 30.
- D. Extremely fast acting fuses: Bussmann Type KAB with ampere ratings of 1, 3, 6, 10, 15, 20, or 30.

#### 2.11 CONTROL RELAYS

- A. General service, industrial grade auxiliary relays rated 600-volt.
- B. Contacts shall be reversible from N.O. to N.C. in field.
- C. Timing relays for critical service: Agastat Series 7000.

#### 2.12 CONTROL SWITCHES

- A. Multistage, rotary-type rated 120 volts ac or 125 volts dc, 3 amperes, as required.
- B. Handles shall be black, fixed, modern, pistol grip type. Provide engraved black plastic escutcheon plates with targets.
- C. Provide with colored LED lamps and nameplates as required.

### 2.13 PUSHBUTTONS

- A. Standard pushbuttons shall be heavy, industrial-type rated 120 volts ac or 125 volts dc, 3 amperes, as required.
- B. Provide with colored LED lamps and nameplates as required.

### 2.14 INDICATING LIGHTS

- A. Status indicating lights shall be high-intensity, cluster, LED-type for panel mounting.
- B. Coordinate indicating light colors with indicated conditions as follows. Indicating lights shall be energized when condition exists and shall be de-energized when condition does not exist:
  - 1. Red: Equipment energized: such as motor running, valve open, or breaker closed.
  - 2. Green: Equipment de-energized: such as motor stopped, valve closed, or breaker open.
  - 3. Amber: Equipment abnormality: such as motor trip, breaker trip, or relay trip.
  - 4. White: Monitoring of control power or trip coil: such as lockout relay trip coil monitor or breaker trip coil monitor. Light is on during normal circuit operation and off during loss of power or loss of coil.
  - 5. Blue: Loss of control power.

### 2.15 ALARM AND TRIP CONTACTS

- A. Alarm contacts for remote annunciation shall be suitable for operation at 120 volts ac and 125 volts dc. Contacts shall be rated at least 0.5-ampere make and break, minimum.
- B. Alarm contacts shall be normally closed contacts that open to alarm condition.
- C. Trip contacts for remote trip shall be suitable for operation at 125 volts dc and shall be rated 5 amperes make or break, minimum.

### 2.16 SEPARATELY MOUNTED COMBINATION MOTOR STARTERS

- A. Enclosed, 3-phase, full-voltage, nonreversing, unless indicated otherwise.
- B. Complete combination starter shall have minimum interrupting rating of 65 kA or greater if specified elsewhere or indicated on Drawings.
- C. Starter enclosures shall have enclosure NEMA rating specified herein.
- D. Provide combination starter with microprocessor-based contactor and integral electronic overload protection; minimum size shall be NEMA 1.
- E. Each phase shall have microprocessor-monitored current sensor for motor running overload, phase loss and phase unbalance protection.
  - 1. Provide Class II ground fault protection; set to 20% of maximum continuous ampere rating and have delay of 20 seconds and run delay of 1 second to prevent nuisance trip on start.
  - 2. Single-speed starters shall be furnished with 3 current sensors. 2-speed starters shall be furnished with 6 current sensors.
- F. Starters shall be furnished with motor circuit protectors (MCP) rated 600-volt.
  - 1. Each breaker shall be manually operated with quick-make, quick-break, trip-free toggle mechanism.
  - 2. Starters shall have external manual breaker-operating handle with provisions for up to 3 padlocks.
  - 3. Access door shall be interlocked with motor circuit protector, so door cannot be opened while breaker is closed except by interlock override.
  - 4. Starter contactor shall mechanically operate auxiliary contacts. Each starter shall include auxiliary contacts required for application, plus 2 spare NO and 1 spare NC contacts.

5. Provide membrane-style pushbutton control module and LED lights, if indicated on schematics, to control starter functions and indication. Pushbuttons and LEDs shall be clearly identified.
6. Verify and match control power transformers, overload protection, and sizes of starters to actual equipment furnished.
7. Size control power transformers (CPT) to supply control circuit and any additional loading simultaneously. Minimum CPT size shall be 100 volts-amperes for Size 1 starters and 150 volts-amperes for Size 2 and larger starters.
8. CPTs shall have primary leads protected, and one secondary lead protected and one secondary lead grounded. Provide DIN rail-mounted, miniature circuit breakers for protection. Fuses not allowed.
9. Starters for systems with system voltage of 120 volts or less shall not require CPT.
10. Two-speed starters and reversing starters shall be mechanically and electrically interlocked so only one set of contacts can be closed at any one time.

#### 2.17 LOCAL SEPARATE MANUAL STARTERS

- A. Separately enclosed manual starters, shall be provided with adjustable, bimetallic, Class 10 ambient-compensated, integral overload relay and fixed magnetic short-circuit trip mechanism designed to trip at 12 times maximum current rating.
- B. Starters shall use high-conductivity copper for current carrying parts.
- C. Size starters for motors served in accordance with NEC and manufacturer's recommendations.
- D. Mount manual starters in enclosures with NEMA rating for area as specified herein.
- E. If applicable, starters shall be UL-listed and CSA-certified for group installations.
- F. Accessories shall be available for auxiliary contacts, trip alarm, under-voltage release, and shunt trip for field installation.
- G. Starters shall be pad-lockable with 3 padlocks in "On" and "Off" position.

#### 2.18 LOCAL SEPARATE CIRCUIT BREAKERS

- A. Provide 3-pole, molded-case, separately enclosed circuit breakers of not less than interrupting rating shown on Drawings at rated voltage.
  1. Provide with thermal and instantaneous trip elements.
  2. Breakers shall use high-conductivity copper for current carrying parts. Breaker enclosures shall have NEMA type enclosure as specified.
- B. Each breaker shall be manually operated with quick-make, quick-break, and trip-free toggle mechanism. Thermal elements shall withstand sustained overloads and short-circuit currents without injury and without affecting calibration.
- C. Circuit breakers shall have "On," "Off," and "Tripped" indication and shall be pad-lockable with 3 padlocks in "On" and "Off" position.
  1. Breakers rated over 70 amperes shall be rated 100% and have adjustable electronic trip units.
  2. Breakers shall be capable of adding alarm, lockout, shunt trip, and under-voltage as options.

#### 2.19 LOCAL SEPARATE DISCONNECT SWITCHES

- A. Three-pole, nonfusible, heavy-duty, rated 600-volt with continuous current rating as shown on Drawings and as required by load.
  1. Type: Either molded-case or blade.
  2. Switches shall use high-conductivity copper for current carrying parts.

- B. Switches shall be positive, quick-make, and quick-break mechanisms.
  - 1. Switch assembly plus operating handle shall be integral part of enclosure base.
  - 2. Each switch shall have handle whose position is easily recognizable and which can be locked in "On" and "Off" position with 3 padlocks. "On" and "Off" positions shall be clearly marked.
- C. Switches shall be UL-listed and horsepower rated. Where applicable, switches shall have defeatable door interlocks that prevent door from being opened while operating handle is in "On" position.

## 2.20 DC MOTOR STARTERS

- A. Magnetic starters for dc service shall be suitable for starting 125 volts dc rated motors unless stated otherwise.
- B. Starters shall have same features and capabilities, where applicable, as ac combination and manual starters.
- C. Size starters for motor served. Coordinate system requirements with equipment manufacturer's requirements.
- D. Manufacturer: General Electric or Cutler Hammer.

## 2.21 AUXILIARY POWER TRANSFORMERS

- A. Provide separately mounted transformers as shown on Drawings.
- B. Windings shall be copper.
- C. Transformers shall be self-air-cooled, dry-type, capable of wall- or floor-mounting, and enclosed for wiring connection by conduit. In areas where dust and dirt may be normally present, use encapsulated-type transformers.
- D. NEMA enclosure type protection shall be as specified herein.
- E. Provide at least 2 full KVA capacity voltage taps above and 2 full KVA capacity taps below nominal rating. Each tap shall be 2.5% step.
- F. Transformer shall be capable of at least 150°C rise above rated site maximum ambient without degrading transformer life.
- G. Transformers shall be capable of continuous operation at rated kVA with normal life expectancy as defined in ANSI C57.
- H. Sound level shall not exceed NEMA maximum average sound level.
- I. Enclosure shall be sheet steel with corrosion-resistant finish and manufacturer's standard color.

## 2.22 POWER FACTOR CORRECTION CAPACITORS

- A. Where capacitors are specified, capacitors shall be rated 3-phase, delta configuration, and rated for voltage of system to which they will be connected. Capacitors shall not contain PCBs.
- B. Enclosures shall be as required for areas in which they are installed and in accordance with requirements of this Specification.
- C. kVA sizes indicated on Drawings are approximate. Actual rating shall be verified with manufacturer in order to improve power factor to 95% at full load.

- D. Capacitors shall be complete with discharge resistors and fuses.
- E. Mount as close as physically possible to motors, preferably in main termination enclosure. Coordinate installation of capacitors with Engineer.

## 2.23 PLATES AND COVERS

- A. Provide finish plates and covers of appropriate type and size for wiring and control devices, signal, and communication outlets.
- B. Mark each plate and cover to show circuit and panel designation. Unless indicated to be engraved plate, use self-sticking, clear membrane, UV-resistant labels with typed black letters. Handwritten labels not allowed.
- C. Coordinate color with adjacent surfaces.
- D. Raised cover galvanized steel plates shall be acceptable for use on surface-mounted outlet boxes in unfinished areas where weatherproof plates are not required.
- E. For weatherproof installations, cover plates shall be gasketed and rated for NEMA Type 4 installation.
- F. Device plate mounting hardware shall be countersunk and finished to match plate.

## 2.24 WIRING DEVICES

- A. Where more than one flush device is indicated in same location, mount devices in gangs under common plate.
- B. Switches for control of ac lighting panel load circuits, single-pole, 3-way, and 4-way, shall be premium, heavy-duty specification-grade, and meet FS W-S-896E. Switches shall be rated for use at 120 or 277 volts and 20 amperes minimum.
- C. Device color, if not shown on Drawings, shall be coordinated to match adjacent finishes.
- D. Wall switches requiring pilot light indication shall have red LED pilot light when toggled "On."
- E. Pulse control of lighting contactors shall be 20 amperes, 120/277 volts, momentary, double-throw, and center "Off."
- F. Standard convenience outlets: Premium, heavy-duty, specification-grade, duplex, 3-wire, grounding, 20-ampere, 125-volt for 120-volt circuits, and rated 250-volts for 240 or 208-volt circuits.
- G. Ground fault circuit interrupter (GFI) receptacles: Duplex, 20-ampere, and 125 volts, feed-through type.

## 2.25 PANELBOARDS

- A. Dead-front, circuit breaker type, rated for voltage, phase, with main lugs or main breaker as indicated on panel schedules.
- B. Enclosure shall be NEMA-rated for installation location and capable of flush or surface mounting.
- C. Enclosure cover and access door shall be hinged with breaker operating handles accessible through latchable and lockable door.
- D. Typed panel directory located inside door shall have panel and circuits function clearly identified. Handwritten panel schedules not allowed.

- E. Provide main and neutral buses insulated from cabinet with separate ground bus. Bus material shall be copper. Ground bus shall be similar to neutral bus in size and number of conductor terminating positions.
  - 1. Bond ground bus to panelboard enclosure by copper ground strap or copper conductor of appropriate size. Bond neutral bus to ground bus in accordance with requirements of NEC.
  - 2. Grounding bus connection to enclosure by removable screws not allowed.
  - 3. Bus shall be capable of terminating clamp type lugs for neutral cable in each supply conduit, and connections for neutral cable in each load circuit.
  - 4. Neutral bus shall be fully rated, unless specified otherwise.
  - 5. Isolated ground panelboards: As specified above, except isolated ground bus shall be bonded, by insulated ground conductor, back to source of separately derived system. Do not bond isolated ground bus to panelboard enclosure unless this is first point of grounding for separately derived system.

## 2.26 CIRCUIT BREAKERS

- A. Molded-case, thermal-magnetic, bolt-in, individually front replaceable, and shall visibly indicate "On," "Off," and "Tripped" position.
- B. Branch circuit breakers used for lighting circuits shall be switch duty rated, "SWD."
- C. Breakers having multiple poles shall be manufactured as common trip type.
- D. Interrupting rating shall be not less than interrupting rating of panelboards, and not series rated to achieve required short circuit interrupting rating.
- E. Provide handle clips for 10%, or minimum of 2 whichever is greater, for breakers to prevent casual operation. If no breakers are indicated for installation, then provide on breakers labeled as spare.
- F. Breakers, and provisions for future breakers, shall be provided in quantities, poles, and ampere ratings shown on Drawings.
- G. Molded-case circuit breakers used in ac and dc panelboards and ac load centers shall be bolt-on type, G-frame size.

## 2.27 FINISHES

- A. Manufacturer's standard coating systems shall be factory-applied. Coating systems shall provide resistance to corrosion caused by weather and industrial environments.
  - 1. Surfaces inaccessible after factory or field assembly shall be protected for life of equipment.
  - 2. Painted surfaces shall be filled to provide smooth, uniform base for painting.
  - 3. Surfaces requiring field welds shall not be coated within 3" (75 mm) of field weld.
- B. Coating material and application techniques shall conform to regulations of air quality management agency having jurisdiction.
- C. Exterior surfaces of control and electrical equipment, including panels, cabinets, switchgear, transformers, and motors shall be manufacturer's standard colors unless specified otherwise.
- D. Apply high-temperature coating systems to uninsulated equipment operating at temperatures at or above 200°F (93°C).

## 2.28 RUST-INHIBITOR COMPOUNDS

- A. Uncoated machined and ferrous surfaces subject to corrosion shall be protected with rust-inhibitor compounds.

- B. Rust-inhibitor compounds used to protect surfaces of equipment and piping exposed to feedwater or steam shall be completely water-soluble.
- C. Surfaces to be field welded shall be coated with consumable rust-inhibitor compounds that will not affect quality of weld.
- D. External gasket surfaces, flange faces, couplings, rotating equipment shafts and bearings shall be thoroughly cleaned and coated with rust-inhibitor compounds.

## 2.29 GALVANIZING

- A. Galvanized structural steel members and steel assemblies shall be pickled after fabrication. Remove scale, rust, grease, and other impurities, then hot-dip galvanized in accordance with ASTM.
- B. If galvanized member is to be bolted, structural bolts shall be galvanized in accordance with ASTM.

## 2.30 IDENTIFICATION AND TAGGING

- A. Conduits inside manholes, hand holes, building entrance pull boxes, and junction boxes shall be provided with 19-gage (1 mm) stainless steel identification tags, with 1/2" (13 mm) stamped letters and numbers.
  - 1. Attach conduit identification tags with stainless steel banding. Tag position shall be readily visible for inspection.
  - 2. Tags shall provide, as minimum:
    - a. Circuit origination and destination.
    - b. Voltage.
    - c. Number of conductors in accordance with phase.
    - d. Number of phase conductors.
- B. Cables passing through or terminating in manholes, hand holes, and pull boxes shall have 19-gage (1 mm) stainless steel identification tags with stamped lettering that provides circuit identification information.
- C. Provide power, control, and instrumentation cables with permanent type identification markers with typed cable numbers and from/to information at each point of termination. Cable numbers and from/to information will be provided for circuits not associated with low-voltage panelboards.
  - 1. Position cable markers to be readily visible for inspection.
  - 2. Cable numbers shall match those as shown on Drawings.
  - 3. Provide wire tags at each termination point for each conductor. Tags shall be permanent, wrap around, heat-shrinkable type with typewritten information.
- D. Color-code power conductors with electrical tape or provide with colored jacket.
  - 1. Source voltage of 208Y/120 volts:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Neutral: White.
  - 2. Source voltage of 120/240 volts:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Neutral: White.
  - 3. Source voltage of 480Y/277 volts:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Gray.

4. Source voltage of 240/120-volt delta: High-leg systems shall not be used without Engineer approval.
5. Service entrance and equipment ground conductors shall be bare copper or green insulated conductor. Equipment bonding conductors shall be bare copper.
6. Isolated ground conductors shall be insulated; green in color with integral yellow stripe. No substitutions.

### 2.31 EQUIPMENT NAMEPLATES

- A. Laminated white-over-black plastic such that face is white with black letters, with 1/8" (3 mm) engraved letters securely fastened with minimum of 2 self-tapping, stainless steel screws.
- B. Motor starters, either separately mounted or contained in motor control centers, shall have nameplates identifying related equipment. Where separate control and indicating lights are used, starters shall have engraved or etched legends ("start", "stop", etc.) as shown on Drawings.
- C. Provide control stations with nameplates identifying related equipment. Control and indicating lights shall have engraved or etched legends as shown on Drawings.
- D. Circuit breakers within main switchboards and distribution switchboards shall be provided with nameplates identifying related equipment being served.
- E. Fused and nonfused switches shall have 2 front cover-mounted nameplates.
  1. Nameplate containing permanent record indicating switch type, manufacturer's name, catalog number, and appropriate rating for equipment served.
  2. Provide additional nameplate to identify associated equipment.
- F. Panelboards shall have front cover-mounted nameplates identifying panelboard, matching information shown on Drawings and associated panel schedule. Nameplate shall have at least 4 lines of text consisting of:
  1. Line 1: Panel equipment identification number.
  2. Line 2: IEEE Voltage Designation.
  3. Line 3: Appropriate description from which power is derived, (i.e. fed from HP1 through XFMR-LP1).
  4. Line 4: Location of power source, (i.e. PP-1, NW wing).
- G. Lighting and auxiliary power transformers shall have front cover-mounted nameplates identifying transformer, matching information shown on Drawings. Nameplate shall have at least 2 lines of text that consist of:
  1. Line 1: Transformer equipment identification number.
  2. Line 2: Location of derived power source (i.e. fed from MDB, Elec Rm Basement).
- H. Nameplates shall meet requirements of NFPA 70E

### 2.32 HARDWARE

- A. Provide hardware including, but not limited to, anchor bolts, nuts, washers, expansion anchors, wire nuts needed for installation.
- B. Hardware smaller than 3/4" (19 mm) shall match NEMA standard size bolt holes on motors and electrical equipment.

### 2.33 LOGIC SYSTEMS FACTORY TESTING

- A. Prior to shipment, test electrical equipment containing solid-state logic systems in accordance with manufacturer's standard tests for minimum of 120 hours under power.

1. Components tested shall include electronic devices; power supplies, input-output devices, operator interface devices, and interconnecting cables provided with system.
  2. System shall be tested as complete assembly. Testing of individual components or modules not allowed as system tests.
- B. System test shall include:
1. Means of confirming logic or mathematical design response of system by simulating changes in system input.
  2. Test shall repeatedly cycle system through operations system will be expected to perform in service with loads on various components equivalent to those which will be experienced in actual service.
  3. Adjustment of power source voltages to high and low limits. Verify correct operation of system at both high and low power source voltage limits.
- C. System shall be tested and verified capable of providing surge withstand capability in accordance with requirements of ANSI C37.90.1.
- D. Perform tests with solid-state logic system exposed to ambient temperature appropriate to service for which associated electrical equipment is designed.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION OF SITE**

- A. Contractor shall be responsible for familiarity with Project Site conditions. Equipment furnished and installed shall be capable of withstanding most severe conditions that will be encountered.

#### **3.02 PROTECTION OF WORK**

- A. Protect installed Work and provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- B. Damage occurring to building or equipment during installation shall be repaired or replaced to conditions existing prior to damage at no additional cost or delay to project or Owner.

#### **3.03 INSTALLATION**

- A. Install equipment and materials in accordance with manufacturer's recommendations and Drawings.
- B. Details for equipment and systems installed in accordance with industry standard techniques will not be furnished.
- C. Installation details furnished on Drawings shall be followed unless found to be unsafe, inappropriate for equipment specified, or unachievable due to site conditions.
- D. Except as otherwise specified or indicated on Drawings, equipment shall be installed plumb, square, and level.
- E. Sheet metal junction boxes, equipment enclosures, sheet metal raceways, and similar items mounted on earth-bearing walls shall be separated from wall not less than 1/4" (6 mm) by corrosion-resistant spacers.

#### **3.04 TRIP SETTING COORDINATION**

- A. Motor overload protection shall be selected and set by Contractor based on final motor nameplate information. Size motor circuit protectors to coordinate with motor starting characteristics and overload protection. Submit summary of settings to Owner, list:

1. Equipment project identification number.
2. Nameplate information.
3. Overload device trip range.
4. Overload device setting.
5. Trip device rating.
6. Trip device setting if different from rated value.

### 3.05 CABLE

- A. Prior to installation of each cable or cable group into assigned raceway, verify that raceway has been correctly sized.
  1. Where raceway is not indicated in circuit schedule or on Drawings, size in accordance with requirements of NEC.
  2. If raceway size indicated on Contract Documents is inadequate, notify Engineer.
- B. Replace cables pulled into wrong raceway or cut too short to rack and train.
- C. Do not reinstall cables installed in wrong raceway and removed. Discard cables unless inspected and accepted by Owner's Representative in writing.
- D. Carefully lay or pull circuits in cable tray so neither cables nor tray is damaged.
- E. Protect cables from dirt, water, oil, damaging chemicals, and from physical injury prior to, and during installation.
- F. Cables shall be cut sufficiently long to conform to contour of trays, with particular attention paid to vertical inside bends.
- G. Remove excessive slack so cables lie parallel to sides of trays.
- H. Multiple single-conductor power cables No. 1/0 AWG (50 mm<sup>2</sup>) or larger installed in cable tray that constitute single power circuit shall be grouped together in triplexed or quadriplexed arrangement. Maintain cable spacing to be 2.15 x O.D. of largest conductor in group or adjacent group.
- I. Multiconductor power cables No. 4/0 AWG (120 mm<sup>2</sup>) or larger installed in cable tray shall be installed in single layer with maintained spacing of not less than 1 cable diameter of largest cable.
- J. Fasten cables to cable tray with rated nylon ties to hold cables in place.
- K. Perform fishing and pulling with flexible round metal tape, CO<sub>2</sub> propelled polyethylene cord, nylon rope, or manila rope.
- L. Cable damage caused by improper pulling tension and excessive sidewall pressures shall be considered for any cable pulls that require use of mechanized cable pulling machine, whether installed underground or overhead.
  1. NEC requirements shall be used as guideline. Calculations shall be performed for duct bank runs over 300' (90 m), and for installations in conduit over 100' (30 m).
  2. Monitor pulling tension during installation of cable. Tension shall not exceed maximum recommended by cable manufacturer.
  3. To avoid damage from excessive sidewall pressure at bends, pulling tension shall not exceed cable manufacturer's recommendation.
  4. Pulling mechanisms, manual or power type, shall have rated capacity in tons legibly marked on mechanism.
  5. During installation, observer shall constantly watch dynamometer and record maximum tension achieved during pull.
    - a. If excessive strain develops, stop pulling operation at once. Determine difficulty and correct.
    - b. Provide records of dynamometer readings to Engineer.

- c. Inform Owner prior to cable pulls.
  - 6. Do not use woven wire cable grips. Use only pulling eyes for pulling cables.
  - 7. As soon as cable is pulled into place, remove pulling eyes and reseal cable.
- M. Insert reliable nonfreezing type of swivel or swivel connection between pulling rope and eye to prevent twisting under strain.
- N. Only use lubricants as recommended by cable manufacturer. Water-based lubricants not allowed.
- O. Outside of each cable reel shall be carefully inspected. Remove protruding nails, fastenings, or other objects that might damage cable.
- 1. Perform visual inspection for flaws, breaks, or abrasions in cable sheath as cable leaves reel. Pulling speed shall be slow enough to permit inspection.
  - 2. Damage to sheath or finish of cable shall be sufficient cause for rejecting cable.
  - 3. Cable damaged during installation shall be replaced at no expense to Owner.
- P. Permanent radius of each bend after cable installation shall be in accordance with manufacturer's recommendations.
- Q. Cable supports and securing devices shall have bearing surfaces located parallel to surfaces of cable sheath. Install to provide adequate support without deformation of cable jackets or insulation.
- R. Provide adequate cable end lengths. Properly install in junction boxes and manholes to avoid longitudinal strains and distorting pressures on cable at conduit bushings and duct end bells.
- S. Final inspection shall be made after cables are in place. Where supports, bushings, and end bells deform cable jacket, provide additional supports.
- T. Splices, joints, and connections shall be made only in accessible junction boxes in accordance with methods specified and instructions of cable manufacturer. Splices not allowed unless shown on Drawings.
- U. Rough-in wiring terminated in junction boxes shall have at least 8" (200 mm) of free conductor coiled in box for connection to equipment and receptacles.
- V. Circuit information for circuits originating from panelboards is indicated on panel schedules. Other circuits are identified on circuit schedule.
- 1. Do not combine receptacle loads with lighting loads.
  - 2. Circuits fed from panelboards shall not be combined with circuits from circuit schedule.
- W. Panelboard circuits are indicated as individual runs. Circuits may be combined into common conduits in accordance with rules of NEC. Perform work associated with combining of circuits at no additional cost to Owner.

### 3.06 WIRING DEVICES, BOXES, AND FITTINGS

- A. Install galvanized or cadmium plated, threaded, malleable iron boxes and fittings in:
- 1. Embedded in concrete walls, ceiling, and floors.
  - 2. Outdoor exposed faces of masonry walls.
  - 3. Locations where weatherproof cover is required by code or this specification.
- B. Install galvanized or cadmium plated sheet steel boxes in:
- 1. Indoor exposed faces of masonry walls.
  - 2. Interior partition walls.
  - 3. Joist supported ceilings.
- C. Rigid PVC device boxes shall be installed in exposed nonmetallic conduit systems.

- D. Telephone and communication conduit systems shall have separate junction boxes and pull fittings.
- E. Install fire system wiring in dedicated conduit system.
- F. Finish openings so standard sized cover plates can be used. Oversized plates not allowed.
- G. Mount wall switches 3'-6" (1050 mm) above finished floor or grade unless specified otherwise. After circuits are energized, test wall switches for proper operation.
- H. Outlets:
  - 1. Standard mounting height: 18" (450 mm) above finished floor, unless specified otherwise.
  - 2. Outlets outdoors, garages, basements, shops, storerooms, and other rooms where equipment may be hosed down: 4'-0" (1200 mm) above finished floor or grade.
  - 3. Surface-mount welding receptacles 4'-0" (1200 mm) above finished floor or grade.
  - 4. After circuits are energized, test each receptacle for correct polarity.
  - 5. Test GFCI receptacles for proper operation.
  - 6. Mount wall thermostats 5'-6" (1650 mm) above finished floor unless noted otherwise. Thermostats mounted shall be suitably insulated from wall temperatures.
- I. Communication outlets shall be 18" (450 mm) above finished floor unless required otherwise. Outlets outdoors, garages, basements, shops, storerooms, and rooms where equipment may be hosed down shall be 4'-0" (1200 mm) above floor.
- J. Clock outlets shall be located 7'-0" (2.13 m) above finished floor or grade.

### 3.07 GROUNDING AND BONDING

- A. Electrical system and equipment grounding shall be installed in accordance with NEC and shall conform to following, where applicable:
  - 1. Ground conductors shall be bare or green-insulated in accordance with NEC.
  - 2. Cable shall be soft-drawn copper or copper bar, sized in accordance with drawings and NEC, but not smaller than No. 12 AWG.
  - 3. Ground cable splices and joints inaccessible upon completion of construction shall meet requirements of IEEE 837 and shall be exothermic weld or compression system type.
  - 4. Ground cable through exterior building walls not in conduit shall enter within 3' (1 m) below finished grade and shall be provided with water stop. Installation of water stop shall include filling space between strands with solder and soldering 12" (300 mm) copper disc over cable.
  - 5. Ground cable near base of structure shall be in undisturbed earth and as far from structure as excavation permits, but not closer than 6" (150 mm).
  - 6. Copper ground conductor in addition to conduit connection shall ground each piece of electrical equipment.
  - 7. Copper or high-conductivity copper alloy ground lugs or clamps shall make ground connections to equipment and ground buses. Connections to enclosures not provided with ground buses or ground terminals shall be made by clamp-type lugs added under permanent assembly bolts or under new bolts drilled and added through enclosures other than explosionproof, or by grounding locknuts or bushings. Ground cable connections to anchor bolts; against gaskets, paint, or varnish; or on bolts holding removable access covers not permitted.
  - 8. Bond grounding system to water piping by connection to first flange inside building from main that will form good ground connection. Make connection with copper bar or strap by drilling and tapping flange and providing bolted connection.
  - 9. Ground conductors on equipment shall be formed to contour of equipment and firmly supported.
  - 10. Ground rods not described elsewhere shall be minimum 5/8" (16 mm) diameter by 10' (3.0 m) long, with copper jacket bonded to steel core.
  - 11. Make connections to ground grid where shown on Drawings.
  - 12. Verify connections by performing continuity checks.

### 3.08 POWER FACTOR CORRECTION CAPACITOR

- A. Provide capacitors for motors where shown on Drawings.
- B. Do not connect capacitors to load side of solid-state starters, reduced-voltage autotransformer starters with open transition, multispeed starters, or adjustable frequency drives.
- C. Furnish galvanized angle-iron mounting stands to mount capacitors at least 4" (100 mm) above mounting surface and as close to motors as physically possible without interference for installation or maintenance.

### 3.09 FIRE PROOFING AND FIRE RATINGS

- A. Maintain fire-resistive integrity during construction.
- B. Penetrations through fire-resistive structures shall be sealed with fire-resistive material compatible with construction penetration.
- C. Where required by codes, local building officials, or fire marshal, furnish UL fire sealing systems and install in accordance with manufacturer's recommendations.

### 3.10 STARTUP AND TESTING

- A. Clean equipment interiors and exteriors prior to start-up and testing.
- B. Unless specified otherwise, tests performed shall be standard tests listed by ANSI/IEEE for intended equipment.
- C. Equipment shall be checked and placed in service ready for operation.
- D. Circuits shall be electrically tested after installation. Test power and motor circuits prior to final connection to equipment. Splices shall be complete prior to testing.
  - 1. Provide equipment and labor required for testing.
  - 2. Circuit failing to test satisfactorily shall be replaced or repaired, and retested at no additional cost to Owner.
  - 3. Check power and motor circuits, dc power, and control circuits for:
    - a. Correct terminations.
    - b. Continuity.
    - c. Unintentional shorts and grounds.
  - 4. Check power conductors for correct phasing.
  - 5. Motor circuits shall be checked for proper rotation and motors "bumped" to verify correct machine rotation.
  - 6. Control, instrumentation, and thermocouple wire shall be checked for correct termination, continuity, freedom from shorts or grounds, and identification.
  - 7. Current transformer wiring shall be loop checked by injecting current at one end of loop and checking with clip-on ammeter at each field termination point to assure continuity and phase identification.
  - 8. Voltage transformer wiring shall be tested by applying voltage at one point and checking with voltmeter phase rotation meter and phase angle meter at each field termination point to assure continuity, identification and phase shift.

### 3.11 DEMONSTRATION

- A. Final start-up and check out shall be completed prior to Owner acceptance of project.
- B. Electrical installation shall be complete in every detail and capable of normal operation in presence of Owner or Owner's Representative to verify its readiness.

END OF SECTION

- 1) LD Vance
- 2)

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. Above grade conduit, wireway, boxes, and associated accessories for support, securing, and protection of electrical wiring.

### 1.02 INFORMATIONAL SUBMITTALS

- A. Product Data:
  - 1. List of proposed materials identifying manufacturer and type to be furnished.
  - 2. Manufacturer's catalog sheets, marked as necessary to indicate specific type, model or catalog number for equipment to be furnished for project.
- B. Quality assurance data:
  - 1. Component and accessories data sheets.
  - 2. Installation information.
- C. Such other similar information as Engineer may request.

### 1.03 QUALITY ASSURANCE

- A. Manufacturer's qualifications:
  - 1. Manufacturer shall be manufacturer of major components within assembly and shall be ISO certified.
  - 2. Manufacturer shall have produced similar equipment for a minimum period of 5 years.
- B. Regulatory requirements
  - 1. Equipment shall be designed and manufactured in accordance with applicable requirements of following: NFPA 70; ANSI C80.1, C80.3, C80.4, C80.5; UL 1, UL 6, UL 360, UL 651, UL 797, UL 870, UL 1242; and NEMA TC2, TC3, TC6, TC9, and RN1.
  - 2. Standards of foreign organizations shall not be used without written approval from Engineer.

## **PART 2 PRODUCTS**

### 2.01 SYSTEM DESCRIPTION

- A. Raceway systems and accessories shall include, but not be limited to:
  - 1. Exposed and concealed conduit.
  - 2. Elbows, fittings, and accessories.
  - 3. Hardware for support, securing, and protection.
  - 4. Wireways.

### 2.02 RIGID METAL CONDUIT, STEEL (RGS)

- A. Material: Mild steel tube with continuous welded seam in accordance with ANSI C80.1, and UL 6.
- B. Exterior and Interior protective coating: Metallic zinc applied by hot-dip galvanizing or electro-galvanizing. Apply final coat of transparent zinc chromate to exterior. Exterior and interior coatings applied to conduit shall afford sufficient flexibility to permit field bending without cracking or flaking.
- C. Thread pitch shall conform to ANSI/ASME B1.20.1. Taper shall be 3/4"/ft (62.5 mm/m).
- D. Each length of conduit shall have UL listing label.

- E. Couplings, unions, and fittings: Threaded-type, galvanized steel.
- F. Conduit bodies: Threaded or threadless type, cast metal or malleable iron type with zinc or cadmium coating. Covers shall have solid gaskets and captive screw fasteners.
- G. Running thread not acceptable.

2.03 RIGID METAL CONDUIT, STEEL, POLYVINYL CHLORIDE COATED (PVC-RGS)

- A. Requirements of article "Rigid Metal Conduit - Steel (RGS)" shall apply.
- B. Coating: Apply minimum 40-mil, gray polyvinyl chloride (PVC) coating over exterior and apply urethane coating uniform and consistent to interior of conduit. Internal coating shall be nominal 2 mil thickness. Conduit having areas with thin or no coating, not acceptable. Protect conduit threads by urethane coating. PVC coating shall have been investigated by UL as providing primary corrosion protection for rigid metal conduit.
- C. Fittings, and conduit bodies: Threaded type, PVC-coated. PVC coating on outside of conduit couplings shall have series of longitudinal ribs, 40 mils in thickness, to protect coating from tool damage during installation. Manufacturer of couplings, fittings, and conduit bodies shall be same as conduit manufacturer. Hazardous location fittings shall be manufactured prior to application of plastic coating, and shall be UL-listed.
- D. PVC exterior and urethane interior coatings applied to conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).

2.04 RIGID METAL CONDUIT, ALUMINUM (RAC)

- A. Material: Aluminum alloy No. 6063-T1 in accordance with ANSI C80.5, and UL 6A.
- B. Fittings: Threaded type, aluminum alloy containing not more than 0.40% copper.
- C. Conduit bodies: Threaded or threadless type, fabricated from aluminum alloy or cadmium-plated malleable iron. Covers shall have solid gaskets and captive screw fasteners.
- D. Running thread not acceptable.

2.05 INTERMEDIATE METAL CONDUIT (IMC)

- A. Material: High-grade sheet steel with continuous welded seam.
- B. External protective coating: Metallic zinc applied by hot-dip galvanizing or electro-galvanizing. Coating shall not flake or crack when conduit is bent. Internal coating of enamel or similar material resulting in smooth surface.
- C. Fittings: Threaded or threadless type, galvanized steel or malleable iron.
- D. Conduit bodies: Threaded-type, cast metal, or malleable-iron type, with zinc or cadmium coating. Covers shall have solid gaskets and captive screw fasteners.
- E. Running thread not acceptable.

2.06 ELECTRICAL METALLIC TUBING (EMT)

- A. Material: Hot-dipped galvanized, high-grade steel with continuously welded seam.

- B. External protective coating: Metallic zinc applied by hot-dip galvanizing or electro-galvanizing. Coating shall not flake or crack when conduit is bent.
- C. Internal coating: Baked enamel or similar compound resulting in smooth surface.
- D. Fittings: Rust-resistant steel compression type. Connectors shall have insulated insert in throat. Die-cast aluminum material, and indent or set screw type, are not acceptable.
- E. Conduit bodies: Malleable iron for use with compression type fittings. Set screw type not acceptable.

#### 2.07 FLEXIBLE METAL CONDUIT (FMC)

- A. Material: Galvanized mild steel.
- B. Construction: One continuous length of steel strip of uniform weight and thickness and shaped in interlocking convolutions; fabrication shall result in smooth interior and exterior surfaces, reduced or full wall.
- C. Fittings: Cadmium-plated steel, malleable iron, or zinc alloy. Screw in type, 1/2" (13 mm) and 3/4" (19 mm) shall have high-density polypropylene liners.

#### 2.08 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Material: Mild steel, galvanized.
- B. Construction: One continuous length steel strip of uniform weight and thickness and shaped in interlocking convolutions; fabrication shall result in smooth interior surface.
- C. External coating: Provide outer jacket of tough extruded polyvinyl. Jacket shall be positively locked to steel core and be sunlight resistant and listed as oil resistant.
- D. Continuous integral grounding strip: Required in sizes 1-1/4" (31 mm) and smaller. Ground wire shall be required for larger sizes.
- E. Fittings: Cadmium or zinc-plated steel or malleable iron. Compression type with tapered hub and synthetic rubber gasket and ground ferrule for making positive ground contact with steel core, designed to prevent outer jacket from pulling away from steel core. Connectors shall have insulated insert in throat. Suitable for grounding through 1-1/4" (31 mm) trade size, provide ground wire lug for sizes 1-1/2" (38 mm) and larger.

#### 2.09 RIGID NONMETALLIC CONDUIT, POLYVINYL CHLORIDE (PVC)

- A. Material: PVC Schedule 40, and Schedule 80. Schedule 40 shall be rated for above-grade installation.
- B. Fittings, elbows, and accessories: Connect to conduit by solvent-type cement process. Material shall be same as conduit.
- C. Transition for connection of plastic conduit to rigid metal conduit shall be threadless solvent-type cement connection to PVC, with threaded connection to rigid metal conduit.

#### 2.10 REINFORCED THERMOSETTING RESIN CONDUIT (RTRC)

- A. Material: Epoxy-based resin system using anhydride-curing agent. Conduit shall be UL 1684 listed.
- B. Conduit shall consist of continuous E-glass roving. Additives for increasing flame spread and lowering smoke density shall be halogen free.

- C. Carbon black shall be used as ultraviolet inhibitor to protect conduit and fittings.
- D. Dielectric strength shall exceed 400 volts/mil when tested in accordance with ASTM D149.
- E. Fittings, elbows, and accessories shall be from same manufacturer, and be manufactured from same process, using same methods and chemicals as pipe. Plastic duct plug may be PVC.
- F. Conduit bodies shall be manufactured using compression molding process using vinylester resin with reinforcement glass. Bodies shall be fire resistant in accordance with UL 1684 and be halogen free.
- G. Provide in standard trade sizes, minimum 3/4" (19 mm).
- H. Rated for cables operating up to 90°C installed within.
- I. Joining system: As recommended by manufacturer to maintain UL listing of components and system. Method shall comply with requirements of installed location.
- J. Consult with manufacturer for acceptability of use for particular application.

#### 2.11 ELECTRICAL NONMETALLIC TUBING (ENT)

- A. Material: Blue, red, or yellow PVC; UL-listed.
- B. Construction: Pliable, corrugated raceway of circular cross-section, extruded from PVC resin.

#### 2.12 PULLBOXES AND JUNCTION BOXES

- A. General use areas, protected or indoor: Galvanized sheet steel with a metal thickness meeting UL 50. Provide removable covers attached with round head silicon bronze machine screws.
- B. Process or wet locations, indoor or outdoor: Galvanized steel or aluminum with gasketed covers attached with stainless steel hardware using raintight hubs.
- C. Hazardous areas: UL-approved for area classification.
- D. Where required for elbows, fittings, and accessories to be furnished by same manufacturer as conduit, boxes shall also be furnished by conduit manufacturer or by supplier approved by manufacturer.

#### 2.13 WIREWAY

- A. Metal gage thickness shall conform to NEC.
- B. NEMA 1: Minimum 16-gage steel with baked enamel finish, hinged or removable covers with captive stainless steel screws.
- C. NEMA 3R: Minimum 16-gage galvanized steel with baked enamel finish, gasketed drip-shield cover, with stainless steel screws, weatherproof.
- D. NEMA 4X: Minimum 14-gage Type 304 stainless steel with neoprene gasket, hinged cover, stainless steel external screw clamps, and external mounting tabs.
- E. NEMA 12: Minimum 16-gage steel with baked enamel finish with gasketed, hinged cover with stainless steel screws, dust-tight.
- F. Screws shall be guarded to prevent damage to wire installation.

- G. Provide fittings, supports, end plates, and accessories as required.

#### 2.14 SURFACE METAL RACEWAY AND MULTIOUTLET ASSEMBLY

- A. Material: Sheet metal channel with fitted cover. Provide pre-wired receptacles suitable for use as multioutlet assembly where required.
- B. Protective coating: Gray enamel finish, manufacturer's standard paint application.
- C. Fittings: Couplings, elbows, outlet and device boxes, and connectors necessary.

### PART 3 EXECUTION

#### 3.01 INSTALLATION - GENERAL

- A. Coordinate timing of installation and locations of raceway with other trades. Do not block access or impede construction.
- B. Locations of above grade raceway indicated on Drawings are approximate. Coordinate actual locations in field to avoid conflicts with other equipment.
- C. Areas designated for, but not limited to; access, maintenance, hatchway, tube removal, and expansion shall be kept clear of field-routed raceway.
- D. Exposed raceway runs shall be installed parallel or perpendicular to dominant surfaces with right-angle turns made with symmetrical bends or fittings.
- E. Install exposed raceway minimum of 6" (150 mm) from outside surface of insulation and lagging on hot water pipes, steam pipes, and other heat sources. Install minimum of 12" (300 mm) from uninsulated heat sources. Avoid long runs parallel to heat sources.
- F. Use expansion fittings where necessary. When expansion or deflection will be greater than 6" (152 mm) or greater than fitting is designed to accommodate, provide junction boxes solidly mounted on each side of expansion joint and connect with flexible, liquidtight conduit, or adjust conduit sections to limit expansion to less than 6" (152 mm).
- G. Support raceway independently from equipment, and temporary or movable structures.
- H. At minimum, identify raceways at both ends with raceway numbers provided by Engineer. Markers shall be adhesive, UV-resistance type with 1" (25 mm) high lettering.

#### 3.02 USES AND LIMITATIONS

- A. Refer to NEC for guidelines regarding use, and limitation of each type of conduit. Follow NEC except as specified otherwise herein, or as shown on Drawings.
- B. PVC-RGS: Acceptable for corrosive areas. Install conduit system in accordance with manufacturer's installation manual. Installer shall be certified by manufacturer to install coated conduit.
- C. RAC: Conduit may be used in general-purpose areas.
- D. IMC: Use only for circuits rated 600 volts or less. Do not use in areas deemed corrosive.
- E. EMT: Use for concealed wiring in finished areas associated with lighting and small power circuits rated 600 volts or less. Do not use outdoors in concrete, or in damp or wet locations. Acceptable for use in nonhazardous, indoor, unfinished areas for lighting and communication, and specialty wiring.

- F. FMC: 1/2" (13 mm) minimum size. Use only in dry, interior, noncorrosive, and concealed locations. Maximum length shall be 3' (1 m) for general use, and up to 6' (1.6 m) to light fixtures in concealed locations.
- G. LFMC: 1/2" (13 mm) minimum size; 5' (1.5 m) maximum length.
- H. PVC: Do not use schedule 40 PVC for exposed runs. Schedule 80 PVC sunlight-resistant conduit may be used for exposed runs if approved by Engineer.
- I. RTRC: Use in such installations as, but not limited to, petrochemical, wastewater, chemical, pulp and paper, bridges, tunnels, docks, piers, and cooling tower and vicinity. May be used in other locations with approval from Engineer.
- J. ENT: Acceptable for limited use in nonindustrial applications for low-voltage, nonpower-related circuits; meet requirements of NEC and be acceptable to authority having jurisdiction.
  - 1. Blue - Security or access control.
  - 2. Yellow - Communication.
  - 3. Red - Fire or emergency.
- K. Surface metal raceway and multioutlet assembly: Use in dry, general-purpose areas where shown on Drawings.

### 3.03 RIGID CONDUIT

- A. Conduits not shown on Drawings shall be sized in accordance with NEC.
- B. Conceal conduit in finished areas.
- C. Drainage: Avoid water pockets in conduit runs; provide suitable fittings at low spots in exposed conduit where pockets cannot be avoided. Weep holes not permitted in conduit.
- D. Conduit ends:
  - 1. Cap spare conduits with fittings designed for intended use.
  - 2. Conduit terminating in panels or enclosures where exposed to entrance of foreign material shall be plugged with commercial duct-sealing compound around conductors.
  - 3. Cap conduit ends during construction to prevent entrance of foreign material.
- E. Where practicable, provide 3" (75 mm) stubbed up conduit for conduit entering into bottom of freestanding equipment. Coordinate locations with equipment. Terminate with grounding bushings.
- F. Clean and swab inside of conduit by mechanical means to remove foreign materials and moisture before wires or cables are installed. Cleaning method shall not damage interior surface of conduit.
- G. Bushings: Provide at termination of conduit not terminated in hubs and couplings. Insulating bushings with 150 C rated insulating inserts in metal housings shall be provided on conduit 1-1/4" (31 mm) and larger. Insulating bushings shall be grounding type. Standard bushings shall be galvanized.
- H. Apply coat of zinc chromate to zinc-coated conduits where protective coating is damaged.
- I. Couplings and unions:
  - 1. Threaded conduit couplings shall join metal conduit with conduit ends butted. Where standard threaded couplings cannot physically be used, join metal conduit using conduit unions or split couplings.
  - 2. Use ground-seat type, watertight unions where union may be submerged.
  - 3. Install coupling nut in upper-most union to prevent entrance of water into union when used in vertical or inclined conduit runs.

- J. Bends: Run of conduit shall not contain more than equivalent of three 90° bends, including offsets at outlets or fittings. Use only manufacturer-approved conduit bending equipment. Do not use deformed or crushed conduits.
- K. Threads: Cut ends of conduit with saw; do not use wheel cutter. Conduit end shall have same number of threads as present from factory. Apply coat of zinc chromate to steel conduit threads and apply anti-seize compound containing powdered zinc or lubricating graphite to aluminum conduit threads.
- L. Use expansion joints as required such that no more than 6" (152 mm) allowance for expansion or contraction of conduit occurs.

### 3.04 FLEXIBLE CONDUIT

- A. Connect equipment that moves due to vibration, normal operation of mechanism, or thermal expansion, in relation to supported conduit using flexible conduit. Install junction boxes as required. Provide green ground wire.
- B. Flexible metal conduit 1-1/2" (38 mm) and larger shall be installed with external lugs and external grounding conductor.

### 3.05 SPECIAL FITTINGS

- A. Hazardous areas: Rigid conduit shall be used in areas designated as Class 1 areas classified as hazardous locations in accordance with NEC.
- B. Fittings installed outdoors or in damp locations shall be weathertight. Outdoor fittings shall be of heavy-duty construction.

### 3.06 CONDUIT SUPPORTS

- A. Supports of structural steel or manufactured framing members shall be fabricated from lightweight channel approved by manufacturer for intended use, provide required rods, anchors, inserts, clamps, spacers, shims, bolts and accessories.
- B. Clamps: Galvanized malleable iron 1-hole straps, beam clamps, or other device with necessary bolts and expansion shields.
- C. Adjustable hangers: Use to support horizontal runs only. Use trapeze-type supports for parallel runs of conduit. Install U-bolts at end of each run and at each elbow. Install conduit clamps every third intermediate hanger for each conduit. Hanger rods shall be 3/8" (10 mm) minimum diameter threaded galvanized steel rods.
- D. Conduits supports mounted on concrete surfaces: Fasten with self-drilling tubular expansion shell anchors with externally split expansion shells, single cone expanders, and annular break-off grooved chucking cones.

### 3.07 PENETRATIONS

- A. Provide required penetrations in floors, walls, or roofs. Penetrations shall be kept to minimum, as small as possible, and installed in neat manner. Surrounding surfaces damaged during installation of penetrations shall be included as part of this work.
- B. Seal penetrations in walls, floors, ceilings, and enclosures. Provide fire stops for electrical raceway penetrations. Maintain original fire rating that existed prior to commencement of work. Do not install fire seal for wire openings until interconnecting wiring of equipment is proven to operate properly.

- C. Sleeves:
  - 1. Provide for passage of conduits through walls, floors, or partitions. Set sleeves in masonry during construction; set sleeves through concrete before placement begins.
  - 2. Material: Rigid conduit or pipe securely fastened in position.
  - 3. Cut sleeve flush with floor where conduit enters equipment enclosure otherwise extend sleeve 3" (75 mm) above floor.
  - 4. Sleeves through exterior building walls: Install conduit in center of sleeve. Pack interior and exterior annular space around conduit with plastic backer rod sized to fit annular space in compression as recommended by backing manufacturer. Seal interior and exterior of joint with acrylic polymer sealant.
  - 5. Sleeves through waterproof construction shall be flanged type.
- D. Penetrations required after walls, floors, or ceilings are constructed shall be provided and grouted or sealed. Openings shall be core-drilled, do not jackhammer.
- E. Patch and finish openings made in existing walls and floors to match original material in composition and appearance.
- F. Cut or punch penetrations in wall panels. External penetration shall be flashed and calked to provide weather tight seal.
- G. Limit penetrations in roofs to applications where required for connection to specific piece of equipment. When required, flash and apply seal material after installation of conduit to provide weathertight bond and seal. Materials shall be compatible with roofing system.

### 3.08 WIREWAY AND BOXES

- A. Installed in accordance with manufacturer's recommendations.
- B. Connections shall be made such that they maintain NEMA rating of enclosure and system.
- C. Locations and quantities shown on Drawings are approximate. Make adjustments as required to eliminate field interferences or to meet requirements of NEC. Provide Engineer with information regarding new locations.
- D. To access interior, locate to permit full removal of covers, or such that doors can be opened more than 100°. Mount at height as indicated, or as required by NEC, whichever is more restrictive.
- E. Support wireways and boxes independently of conduits by means of bolts, screws, rod hangers, and other suitable means.

### 3.09 MULTIOUTLET ASSEMBLY

- A. Space receptacles in multioutlet assemblies at 12" (300 mm) on center or as indicated otherwise. Adjacent receptacles shall be wired on different circuits.

END OF SECTION

- 1) LD Vance
- 2)

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Low-voltage, single-phase, fractional horsepower electric motors rated less than 1/2 hp.

## 1.02 WORK BY OTHERS

- A. Motor foundations and supports.
- B. Receiving, unloading and storing of motors.
- C. Final placement and assembly.

## 1.03 INFORMATIONAL SUBMITTALS

- A. Submit with Bid: Motor list identifying equipment by name, quantity furnished for each type, horsepower or kW rating, voltage requirements, and number of phases.
- B. Quality assurance data: Certified shop test reports.

## 1.04 ACTION SUBMITTALS

- A. Shop Drawings:
  - 1. Manufacturer's standard 8.5" x 11" motor description sheet, to include;
    - a. Frame size.
    - b. RPM at rated load.
    - c. Rated output.
    - d. Maximum driven Load capability.
    - e. Design type.
    - f. Locked rotor current.
    - g. Enclosure type.
    - h. Bearing life expectancy.
    - i. Enclosure type.
    - j. Starting method.
    - k. Number of speeds.
  - 2. Interconnection wiring with terminal points clearly labeled.
  - 3. Interface coordination details.

## 1.05 QUALITY ASSURANCE

- A. Manufacturer's qualifications:
  - 1. Manufacturer shall manufacture major components of motor and shall be ISO certified.
  - 2. Manufacturer shall have produced similar equipment for minimum period of 5 years.
  - 3. When requested by Engineer, provide acceptable list of similar equipment installations complying with requirements of this Section.
- B. Regulatory requirements:
  - 1. Motors shall be in accordance with applicable requirements of NEMA MG-1, NFPA 70, IEEE 112, and UL 1004.
  - 2. Standards of foreign organizations shall not be used without written approval from Engineer.

## 1.06 DELIVERY, STORAGE, AND HANDLING

- A. During delivery and storage, handle equipment to prevent damage, denting, or scoring.

- B. Store equipment and components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

## **PART 2 PRODUCTS**

### 2.01 MANUFACTURERS

- A. Baldor.
- B. General Electric.
- C. Ideal Electric.
- D. Lincoln Motors.
- E. Marathon.
- F. Reliance.
- G. Siemens.
- H. TECO - Westinghouse.
- I. Toshiba.
- J. U. S. Motors.

### 2.02 SYSTEM DESCRIPTION

- A. Motors shall be squirrel-cage, induction type conforming to standards specified.
- B. Supply motors either separate or as integral component of equipment package.
- C. Motors shall meet, as a minimum, the requirements of this specification.
- D. Motors shall be rated to continuously supply power at rated load, and capable of supplying short-term overload condition calculated by multiplying rated horsepower of motor by service factor at rated voltage and frequency.
- E. Motor shall not exceed temperature rise specified when supplying power at nameplate rated horsepower.

### 2.03 ENCLOSURE SYSTEM

- A. Materials potentially exposed to process fluids shall be Type 316L stainless steel, or other materials not susceptible to corrosion.
- B. Do not use copper or copper alloy for air coolers.
- C. Coat copper conductor windings with varnish.
- D. Provide drains and breathers for moisture removal.
- E. Bolts and nuts exposed to environment shall be of Type 316L stainless steel.

### 2.04 VOLTAGE AND FREQUENCY

- A. Nameplate voltage shall be 110, 200, or 240, for operation on a 120, 208, or 240 volt system.
- B. Operating frequency shall be 60Hz.
- C. Service factor:
  - 1. Motors up to 1/8 Hp: 1.4
  - 2. Motors 1/6 up to 1/3: 1.35
- D. Motors shall run successfully at rated load and frequency with  $\pm 10\%$  variation in supply voltage.
- E. Motors shall run successfully at rated load and voltage with  $\pm 5\%$  supply frequency variation.
- F. Motors shall run successfully at rated load with combined variation of supply voltage and frequency that is not more than  $\pm 10\%$  (sum of absolute values) of rated voltage and rated frequency provided 5% frequency variation is not exceeded.
- G. Motors started directly across line shall accelerate to running speed with connected load, with maximum voltage dip of 20%, at starting.

## 2.05 CHARACTERISTICS

- A. Motor shall be sufficient to start and operate connected loads at designated speeds in installed environment, and within operating sequence without exceeding nameplate ratings without use of service factor.
- B. Torque characteristics shall conform to standard NEMA design letter designation and shall be appropriate for mechanical load served.
- C. Motor in-rush current shall correspond to code letters specified in NFPA 70, Table 430.7(B).
- D. Motor efficiency shall be determined in accordance with IEEE Std. 112, Method B. Efficiency at rated load shall meet or exceed the values required by the Energy Policy Act of 1992.
- E. Motor shall be rated for continuous duty at rated load.
- F. Sound level shall not exceed 90dBA at 3' (1 m).
- G. Design for full voltage non-reversing starting, single speed.

## 2.06 MOTOR FRAME

- A. Machine sealing parts in high-accuracy to minimize breathing.
- B. Where motor may be in contact with corrosive or harmful vapors, equip openings with charcoal air filters.
- C. If specified for hazardous area application or required by the packaged equipment, motors shall be enclosed and UL-listed for class, division, and group designation in accordance with NEC Article 500.
- D. Motor frame, end brackets, fan covers, drip shields, and bearing housing shall be corrosion-resistant. Motor supporting feet shall be an integral part of frame.
- E. Provide motors with stainless steel replaceable automatic drainage fittings. Locate drain holes at low point of motor in final mounted position.
- F. Drill and tap for ground lug connection. Locate bolt hole on motor frame, external to, and on same side as terminal box. Provide 1/4-20 unified inch coarse thread (UNC) hole.

- G. For interchangeability, multiple motors provided as part of same system or on same piece of equipment shall have similar motor frame sizes to minimize number of different frame sizes and associated mounting dimensions.

## 2.07 STATOR AND STATOR ASSEMBLY

- A. Maintain assembly in alignment and hold under compression by using through bolts and end rings. Provide high-grade material consistent with specified operating efficiency.
- B. Insulation:
  - 1. Multiple dips and bakes of insulating varnish.
  - 2. Provide additional dips and bakes of insulating varnish and either use of special insulating materials or varnish treatment to prevent growth of fungus and ingress of moisture where required per site conditions.
- C. Windings shall be copper.

## 2.08 ROTOR AND SHAFT ASSEMBLIES

- A. Motor shaft shall be machined, carbon steel capable of transmitting torque produced by motor.
- B. Rotor cage shall be fabricated aluminum, or integrally die-cast aluminum.
- C. Dynamically balance motors by one of following means:
  - 1. Drilling out parent metal in such a manner that structural strength of rotor is not weakened.
  - 2. Use balance washers securely pinned in place.
  - 3. Chiseling, sawing, or use of solder or similar deposit materials to achieve balance is not acceptable.

## 2.09 WINDING INSULATION AND TEMPERATURE RISE

- A. Windings shall be random-wound coils with Class F insulation. Completely insulate windings and winding terminals for ungrounded system.
- B. Temperature rise shall not exceed temperature for motors with Class B insulation at 40°C ambient conditions and elevation up to 3,300 ft (1000 m) elevation.
- C. Temperature rise shall not be exceeded when tested under fully rated nameplate values at site ambient conditions and elevation, but shall not exceed 80°C.

## 2.10 BEARINGS

- A. Provide grease-lubricated ball bearings, vacuum-degassed steel, motor quality.
- B. Construct and provide bearing and bearing housing with slingers and seals to prevent dirt or moisture from entering motor.
- C. Provide interior bearing caps to prevent lubricant from entering motor.
- D. Integrally case bearing supports as part of motor end bell. Rabbet end bell to stator assembly to ensure proper bearing alignment and air gap spacing.
- E. Design bearings so damage does not occur by axial rotor movement during motor startup and shutdown.
- F. Bearings shall be antifriction-type and shall have minimum rated life L10 with median life no less than 50% of L10 life, as defined by ABMA. Reliability of each bearing shall be greater than 90%.

## 2.11 LUBRICATION SYSTEM

- A. System shall be capable of operating at least 8,000 hours without requiring addition of grease or complete change of grease.
- B. Provide system with readily accessible grease inlet and outlet plugs in bearing housings to enable regreasing while motor is in service.

## 2.12 FANS

- A. Fans shall be bidirectional, air-cooled, equipped with externally mounted, nonsparking fan and fan housing suitable for Class 1, Division 2. Fan housing shall be cast iron construction. Rotation shall be indicated by permanent, legible marker mounted on motor.
- B. Fan material shall be nonsparking bronze alloy or conductive plastic. Aluminum, bronze, copper, or copper alloy not acceptable.
- C. Provide stainless steel hardware.
- D. Provide grounding lug inside motor lead terminal box to accommodate incoming earth conductor. Size in accordance with NEMA MG-1.
- E. Motor leads shall have brass, stainless steel ferrules embossed with appropriate lead number, or leads imprint with lead number. Tagging of main leads shall be in accordance with MG-1 2.60 and shall allow determination of motor rotational direction.
- F. Fit with neoprene gaskets.
- G. Main terminal boxes shall be capable of rotation in 90° increments to permit connection on any one of four sides.
- H. Provide motor lead seal and separator gasket between motor frame and terminal box.
- I. Provide main terminal boxes with threaded conduit entrances or hubs for cable glands. Coordinate size with Engineer.
- J. Motor leads shall have oil-resistant insulation.
- K. Electrical connections shall be tinned.

## 2.13 IDENTIFICATION AND TAGGING

- A. Securely attach embossed, stainless steel nameplates with stainless steel screws or pins.
- B. Nameplate shall contain standard information in accordance with NEMA MG-1 40.1 and as follows:
  - 1. Year of manufacture.
  - 2. Type of bearing lubricant and specification number.
  - 3. Arrow indicating direction of rotation for main lead connections.
  - 4. Bearing type and manufacturer's part number.
- C. If identification number cannot be included on motor nameplate, provide separate stainless steel equipment identification nameplate in accordance with equipment identification as provided by Owner.
- D. Motor power and space heater circuits may be derived from different sources. Covers of motor terminal boxes containing space heater leads shall be provided with nameplate reading: "ISOLATE MOTOR AND HEATER CIRCUITS BEFORE REMOVING COVER".

2.14 SOURCE QUALITY CONTROL

- A. Perform shop tests in accordance with NEMA MG-1 for each motor and provide documentation as specified.
- B. Where standard designs have been type tested, type test documentation may be furnished for each of tests instead of performing physical tests.

**PART 3 EXECUTION**

3.01 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.

END OF SECTION

- 1) LD Vance
- 2)

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Low-voltage, 3-phase, fractional and integral horsepower electric motors up to 200 hp.

## 1.02 WORK BY OTHERS

- A. Motor foundations and supports.
- B. Receiving, unloading and storing of motors.
- C. Final placement and assembly.

## 1.03 INFORMATIONAL SUBMITTALS

- A. Product Data: Where instruments and accessories are provided, list by manufacturer and model number Provide operating range for each device.

## 1.04 ACTION SUBMITTALS

- A. Shop Drawings:
  - 1. Complete and accurate Data Sheets.
  - 2. General description and technical data cut sheets.
  - 3. Certified outline drawings that include dimensions, weight, lifting points, center of gravity, enclosure construction, and location of accessories.
  - 4. When thermocouples, RTDs, space heaters, or vibration monitoring is utilized, provide interconnection wiring drawings with terminal points clearly labeled.
  - 5. Complete dimensional drawings for sliding bases.
  - 6. Recommended long term and short term storage requirements and procedures.
  - 7. List of recommended start-up and spare parts for each type of motor, including bearings.

## 1.05 CLOSEOUT SUBMITTALS

- A. Manufacturer's operation and maintenance manuals. Provide, in general:
  - 1. Final reviewed set of drawings listed above.
  - 2. Operating and maintenance procedures.
  - 3. Warranty information.
  - 4. For motors over 100 hp, include bearing and winding temperature limits.
  - 5. Test reports for each motor.

## 1.06 QUALITY ASSURANCE

- A. Manufacturer's qualifications:
  - 1. Manufacturer shall manufacture major components of motor and shall be ISO certified.
  - 2. Manufacturer shall have produced similar equipment for minimum period of 5 years.
  - 3. When requested by Engineer, provide acceptable list of similar equipment installations complying with requirements of this Section.
- B. Regulatory requirements:
  - 1. Motors shall be in accordance with applicable requirements of NEMA MG-1, NFPA 70, IEEE 112, and UL 1004.
  - 2. Motors rated 3/4 hp and above shall be in accordance with IEEE 841.
  - 3. Standards of foreign organizations shall not be used without written approval from Engineer.

**1.07 DELIVERY, STORAGE, AND HANDLING**

- A. During delivery and storage, handle equipment to prevent damage, denting, or scoring.
- B. Store equipment and components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

**1.08 TEMPORARY POWER**

- A. Motors furnished with space heaters shall have heaters connected to temporary source of power capable of being monitored.
- B. Maintain temporary power until motors are installed in final position and normal power source is permanently energized.

**PART 2 PRODUCTS****2.01 MANUFACTURERS**

- A. Baldor.
- B. Ideal Electric.
- C. Lincoln Motors.
- D. Marathon.
- E. Reliance.
- F. Siemens.
- G. TECO - Westinghouse.
- H. Toshiba.
- I. U. S. Motors.

**2.02 SYSTEM DESCRIPTION**

- A. Motors rated 1/2 hp and above shall be 3-phase.
- B. Motors shall be squirrel-cage, induction type conforming to standards specified.
- C. Supply motors either separate or as integral component of equipment package.
- D. As a minimum, motors shall meet requirements of this Specification.
- E. Motors shall be rated to continuously supply power at rated load, and capable of supplying short-term overload condition calculated by multiplying rated horsepower of motor by service factor at rated voltage and frequency.
- F. Motor shall not exceed temperature rise specified when supplying power at nameplate rated horsepower.

**2.03 ENCLOSURE SYSTEM**

- A. Furnish motors with frames 182T and above with lifting eyes arranged so lifting slings do not become entangled in accessories mounted on motor.
- B. Treat materials potentially exposed to process fluids with rust preventing compounds such as Cosmoline, Rust-Veto, or equal.
- C. Do not use copper or copper alloy for air coolers.
- D. Coat copper conductor windings with nonhydroscopic varnish.
- E. Provide drains and breathers for moisture removal.
- F. Bolts and nuts exposed to environment shall be of zinc dichromate.

#### 2.04 VOLTAGE AND FREQUENCY

- A. Motors shall run successfully at rated load and frequency with  $\pm 10\%$  variation in supply voltage.
- B. Motors shall run successfully at rated load and voltage with  $\pm 5\%$  supply frequency variation.
- C. Motors shall run successfully at rated load with combined variation of supply voltage and frequency that is not more than  $\pm 10\%$  (sum of absolute values) of rated voltage and rated frequency provided 5% frequency variation is not exceeded.
- D. Motors shall be capable of operating within design characteristics for system source voltage as specified on Data Sheets.
- E. Motors started directly across line shall accelerate to running speed with connected load, with maximum voltage dip of 20%, at starting.

#### 2.05 CHARACTERISTICS

- A. Motor shall be sufficiently sized to start and operate connected load at motor designated speed within installed environment, without exceeding nameplate ratings.
- B. Intermittent and repetitive duty motors will have an output horsepower capacity that is determined from maximum load power requirements, time length, of duty cycle, and length of time for energized portion of duty cycle.
- C. Do not use service factor to achieve power required to drive load under normal operating conditions.
- D. Torque characteristics shall conform to standard NEMA design letter designation and shall be appropriate for mechanical load served. Motor speed and rotation shall be that required by the driven equipment. Motors shall have torque characteristics adequate to "break away" driven load and to accelerate load to rated speed in length of time that is at least 2 seconds less than the hot locked rotor thermal damage time of motor.
- E. Locked-rotor, breakdown, and pull-up torque, at rated voltage and frequency, shall meet requirements of NEMA MG-1. Locked-rotor shall not exceed values as specified in NEMA MG-1 for appropriate design type of motor.
- F. Motor shall be suitable for number of consecutive cold starts and hot starts as indicated on Data Sheet. As a minimum, motors shall be capable of not less than 4 starts per hour, including 2 successive starts. Motors provided as part of equipment or system having integral or automatic control shall be capable of as many starts per hour as controller will allow.

- G. Motor locked-rotor current shall correspond to code letters specified in NFPA 70, Table 430.7(B) and shall not exceed locked rotor code value as indicated on Data Sheet.
- H. Power factor shall be not less than 0.85 for motors greater than 1 hp operating at motor full-load current, unless approved by the Engineer.
- I. Motor efficiency shall be determined in accordance with IEEE Std. 112, Method B. Test data for similar machines are acceptable instead of individual motor tests. Efficiency at rated load shall meet or exceed values listed in IEEE Std. 841, or as required by Energy Policy Act of 1992, whichever is greater. See Data Sheet for efficiency requirements.
- J. Furnish vertical motors coupled to vertical pumps with nonreversing ratchets and bolted couplings with case drip shields.
- K. Motor shall meet 90 dBA noise level at 3' (1 m), unless specified otherwise.

## 2.06 MOTOR FRAME

- A. Type: Heavy-duty, using cast iron construction.
- B. Machine sealing parts to high-accuracy to minimize breathing.
- C. Where motor may be in contact with corrosive or harmful vapors, equip openings with charcoal air filters.
- D. If specified for hazardous areas, motors shall be enclosed and UL-listed for class, division, and group designation in accordance with NEC Article 500.
- E. Motor frame, end brackets, fan covers, drip shields, and bearing housing shall be corrosion-resistant. Motor supporting feet shall be an integral part of frame.
- F. Provide motors with stainless steel replaceable automatic drainage fittings. Locate drain holes at low point of motor in final mounted position.
- G. Drill and tap for ground lug connection. Locate bolt hole on motor frame, external to, and on same side as terminal box. Provide hole size as follows:
  - 1. Motors up to 50 hp: 1/4-20 unified inch coarse thread (UNC).
  - 2. Motors over 50 hp and up to 200 hp: 3/8-16 UNC.
  - 3. Motors over 200 hp: 1/2-13 UNC.
- H. For interchangeability, multiple motors provided as part of same system or on same piece of equipment shall have similar motor frame sizes to minimize number of different frame sizes and associated mounting dimensions.

## 2.07 SLIDING BASES

- A. Heavy steel in single-unit construction using 2 adjusting bolts.
- B. Heavy-duty bases shall be capable of supporting heaviest weight and largest overhung load for its motor rating without bending, flexing, or vibrating.
- C. Provide permanent means for identifying proper motor frames for which base is suitable.

## 2.08 STATOR AND STATOR ASSEMBLY

- A. Maintain assembly in alignment. Provide high-grade material consistent with specified operating efficiency.

- B. Insulation:
  - 1. Multiple dips and bakes of insulating varnish.
  - 2. Where tropicalization is specified on Data Sheets, provide additional dips and bakes of insulating varnish and either use of special insulating materials or varnish treatment to prevent growth of fungus and ingress of moisture.

C. Windings shall be copper.

## 2.09 ROTOR AND SHAFT ASSEMBLIES

A. Motor shaft shall be machined, carbon steel capable of transmitting torque produced by motor.

B. Rotor cage shall be fabricated aluminum, or integrally die-cast aluminum.

C. Rotor shall be epoxy-coated.

D. Dynamically balance motors by one of following means:

- 1. Drilling out parent metal in such a manner that structural strength of rotor is not weakened.
- 2. Use balance washers securely pinned in place.
- 3. Chiseling, sawing, or use of solder or similar deposit materials to achieve balance is not acceptable.

E. Rotor assembly removal:

- 1. Horizontal motors: Removable through either bell end of motor without requiring removal of stator assembly.
- 2. Vertical motors: Removable from top of motor without requiring dismantling or removal of motor.

## 2.10 WINDING INSULATION AND TEMPERATURE RISE

A. Windings shall be random-wound coils with class of insulation as stated on Data Sheets. Completely insulate windings and winding terminals for ungrounded system.

B. Temperature rise shall not exceed that specified on Data Sheets, at site ambient conditions and elevation.

C. Temperature rise shall not be exceeded when tested under fully rated nameplate values at site ambient conditions and elevation.

D. In accordance with Data Sheet for motor locations where machine may be exposed to high temperature, excessive moisture, corrosion, fungus, insect, or vermin, furnish motors with tropicalization for windings.

## 2.11 BEARINGS

A. Provide grease-lubricated ball bearings, unless type of installation requires otherwise. Ball bearings shall be vacuum-degassed steel, motor quality.

B. Construct and provide bearing and bearing housing with slingers and seals to prevent dirt or moisture from entering motor.

C. Provide interior bearing caps or other suitable means to prevent lubricant from entering motor.

D. Integrally case bearing supports as part of motor end bell. Rabbet end bell to stator assembly to ensure proper bearing alignment and air gap spacing.

E. Design bearings so damage does not occur by axial rotor movement during motor startup and shutdown.

- F. Provide double-shielded bearings using high-temperature greases on motors for air cooler fan applications.
- G. Bearings shall be antifriction-type and shall have minimum rated life L10 with median life no less than 50% of L10 life, as defined by ABMA. Reliability of each bearing shall be greater than 90%.
- H. Size bearings for horizontal motors mounted in vertical position using V-belt drive to accommodate radial load caused by belt drive on shaft extension end.
- I. Shaft and bearings for belt-connected motor shall withstand normal belt pull of equipment furnished and momentary and continuous overloads due to acceleration caused by incorrect belt tension.
- J. Bearings for motors driving vertical pumps, including in-line pumps, shall be designed to carry 200% of maximum thrust, up and down, that pump develops during starting and stopping, and while operating at any capacity on rated performance curve.
  - 1. Minimum momentary up-thrust capacity shall be equal to 30% of down-thrust at rated capacity.
  - 2. Thrust bearings for in-line pump motors shall be at upper end of motor.
- K. Motors used with VFDs shall be inverter duty rated and have motor bearings insulated to help prevent shaft currents to ground through bearings.
- L. Motors rated 200 hp and above for nonVFD applications shall have insulated bearings to prevent against magnetic dissymmetry.
- M. Motors shall have metallic bearing isolators on each bearing.

#### 2.12 WINDING AND BEARING TEMPERATURE MEASUREMENT

- A. Equip each motor stator winding, or each bearing on motors rated 100 hp and larger with the ability to measure temperature, as indicated on the Data Sheets.
  - 1. RTD: Platinum resistance thermometers, rated 100 ohms at 0°C.
  - 2. Thermocouple: Type E, J, K or T as required.
- B. Wire and terminate each RTD or thermocouple lead to terminal blocks located in an externally mounted junction box.

#### 2.13 LUBRICATION SYSTEM

- A. System shall be capable of operating at least 8,000 hours without requiring addition of grease or complete change of grease.
- B. Provide system with readily accessible grease inlet and outlet plugs in bearing housings to enable regreasing while motor is in service.

#### 2.14 FANS

- A. Fans shall be bidirectional, air-cooled, equipped with externally mounted, nonsparking fan and fan housing suitable for Class 1, Division 2. Fan housing shall be cast iron construction. Rotation shall be indicated by permanent, legible marker mounted on motor.
- B. Fan material shall be nonsparking bronze alloy or conductive plastic. Aluminum, bronze, copper, or copper alloy not acceptable.
- C. Provide stainless steel hardware.

#### 2.15 SPACE HEATERS

- A. Provide low surface-temperature space heaters for motors installed outdoors, and motors rated 25 hp or larger installed indoor or outdoor. Mount on inside of motor frame or winding end turns.
- B. Sheath temperature at 110% of rated voltage, when operating at ambient temperature, shall not exceed 200°C or cause motor insulation temperature to exceed 130 °C, whichever is more restrictive.
- C. Space heaters shall be rated and designed to operate at voltages as specified on Data Sheets. Space heaters shall be suitable for installation in hazardous areas as defined by NFPA, if motor is specified to be installed in a hazardous area.
- D. Route space heater power leads to dedicated terminal box for control and space heater leads.

## 2.16 MOTOR TERMINAL BOXES

- A. Equip each motor with terminal boxes.
  - 1. Terminate power leads in terminal box.
  - 2. Provide separate control terminal box and terminate space heater leads and control leads.
  - 3. Where instrumentation is provided, furnish a separate low-voltage terminal box independent of power and control boxes.
- B. Size motor lead terminal box to allow for bending radius and stiffness of motor supply cables, and for terminating grounding conductor in accordance with Data Sheets.
  - 1. Frame size 445T and below: Cast iron terminal box shall be at least twice usable volume specified in NEMA MG-1, and not less than 24 in<sup>3</sup> (393.3 cm<sup>3</sup>).
  - 2. Frame size exceeding 445T: Cast iron, cast steel, or steel plate terminal box sized according to NEMA MG-1, Figure 20-3.
- C. Provide grounding lug inside motor lead terminal box to accommodate incoming earth conductor. Size in accordance with NEMA MG-1.
- D. Motor leads shall have brass, stainless steel ferrules embossed with appropriate lead number, or leads imprint with lead number. Tagging of main leads shall be in accordance with MG-1, Part 2.
- E. Fit with neoprene gaskets.
- F. Main terminal boxes shall be capable of rotation in 90° increments to permit connection on any one of four sides.
- G. Provide motor lead seal and separator gasket between motor frame and terminal box.
- H. Provide main terminal boxes with threaded conduit entrances or hubs for cable glands. Coordinate size with Engineer.
- I. Motor leads shall have oil-resistant insulation.
- J. Terminate main lead electrical connections with tinned lugs.

## 2.17 IDENTIFICATION AND TAGGING

- A. Securely attach embossed or stamped, stainless steel nameplates with stainless steel screws or pins.
- B. Nameplate shall contain standard information in accordance with NEMA MG-1 40.1 and as follows:
  - 1. Year of manufacture.
  - 2. Type of bearing lubricant and specification number.
  - 3. Arrow indicating direction of rotation for main lead connections.
  - 4. Bearing type and manufacturer's part number.

- C. If identification number cannot be included on motor nameplate, provide separate stainless steel equipment identification nameplate in accordance with equipment identification as provided by Owner.
- D. Motor power and space heater circuits may be derived from different sources. Covers of motor terminal boxes containing space heater leads shall be provided with nameplate reading: "ISOLATE MOTOR AND HEATER CIRCUITS BEFORE REMOVING COVER".

#### 2.18 SOURCE QUALITY CONTROL

- A. Perform routine and typical shop tests in accordance with NEMA MG-1 for each motor and provide documentation as specified.
- B. Where standard designs have been type tested, type test documentation may be furnished for each of tests instead of performing physical tests.
- C. In addition to routine tests, perform additional tests for each motor, as indicated on Data Sheets.
- D. In event that motor fails tests, additional tests will be witnessed at discretion of Owner at no additional cost to Owner.
- E. Test results shall be tabulated, submitted, and approved by Engineer prior to shipment.
- F. Defects and defective equipment revealed or noted during testing will be corrected prior to shipment.

### **PART 3 EXECUTION**

#### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.

END OF SECTION

- 1) LD Vance
- 2)

## **PART 1 GENERAL**

### 1.01 SECTION INCLUDES

- A. Low-voltage variable frequency drive (VFD) designed for use on 3-phase squirrel cage induction motor.

### 1.02 INFORMATIONAL SUBMITTALS

- A. Product Data:
  - 1. Completed Data Sheets for each different drive provided. Identify any special accessories required to match with driven load.
  - 2. Complete list an accompanying data for any special equipment required for operation and maintenance of VFD.
  - 3. Receiving, storage, installation, and testing instructions.
- B. Quality assurance data:
  - 1. Submittal document index and submittal schedule.
  - 2. Plots of typical efficiency vs. speed and torque curves.
  - 3. Harmonic analysis calculations specific to each installation showing total harmonic voltage and current distortion at PCC. Information to demonstrate that harmonic currents generated by drives will not cause power distribution system to experience harmonic distortion exceeding limits recommended by IEEE Standard 519. Describe product features and equipment furnished to meet harmonic distortion requirements of this Specification.
  - 4. Mean Time-to-Failure data.
  - 5. Standard production testing procedures for drives, certified factory test data and results after completion of factory testing.

### 1.03 ACTION SUBMITTALS

- A. Shop Drawings:
  - 1. Certified outline, general arrangement, assembly, and installation drawings, that includes front view, dimensions, and weight.
  - 2. Elementary diagrams (3-line diagrams) and schematic control diagrams of complete VFD system showing terminal block terminations, device terminal numbers and internal wiring diagrams.
  - 3. Certified drawings of cable termination compartments showing preferred locations for conduit entry/exit locations and indicating space available for cable terminations.
  - 4. Nameplate drawing.

### 1.04 CLOSEOUT SUBMITTALS

- A. Operation and maintenance manuals. Provide, at minimum:
  - 1. Final copies of documents listed above.
  - 2. Operating and maintenance procedures.
  - 3. Spare parts lists with pricing.
  - 4. Installation field reports and Data Sheets updated to reflect field installation conditions
  - 5. Copies of warranty.

### 1.05 QUALITY ASSURANCE

- A. Design and manufacture according to latest editions of applicable NEMA, UL, NFPA, IEEE, and ANSI standards.
- B. Manufacturer shall be ISO 9001 certified and shall have produced similar electrical equipment for minimum period of 5 years.

- C. When requested by Engineer, provide acceptable list of similar equipment installations complying with requirements of this specification.
- D. Completed drive shall be tested for at least 3 hours with induction motor connected.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. During delivery and storage, handle equipment to prevent damage, denting, or scoring.
- B. Store equipment and components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

### **PART 2 PRODUCTS**

#### 2.01 MANUFACTURERS

- A. ABB.
- B. Allen Bradley.
- C. Cutler-Hammer.
- D. Danfoss.
- E. Robicon.
- F. Toshiba.

#### 2.02 SYSTEM DESCRIPTION

- A. VFD shall convert incoming fixed frequency 3-phase ac power into variable frequency and voltage for controlling speed of 3-phase ac motor.
- B. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for eliminating need for motor derating.
- C. VFD shall be sinusoidal PWM type drive with sensor-less torque vector control capability. Control techniques other than PWM, not acceptable.
- D. Components:
  - 1. Full-wave diode rectifier to convert supply ac to fixed dc voltage.
  - 2. Dc link capacitors.
  - 3. Insulated Gate Bipolar Transistor (IGBT) power section, dual rated for either variable or constant torque applications.
  - 4. VFD shall be microprocessor-based with LED and LCD display to monitor operating conditions.
  - 5. Separate control and power terminal boards.
- E. VFD shall be of modular construction for ease of access to control and power wiring, and maintenance.
- F. Provide in NEMA 1 enclosure for use in normal, nonhazardous industrial environment.
- G. Enclosure doors shall include electromechanical interlocking system with safety switch and electrical interlocks tied to main breaker. Whenever doors are open, safety ground switch shall connect plus, minus, and neutral dc buses to ground to ensure stored energy is discharged.

#### 2.03 DESIGN REQUIREMENTS

- A. Where manufacturer determines an input drive transformer, input filter, or output filter is required to meet installation requirements, they shall also be provided.
- B. Point of Common Coupling (PCC) shall be defined as terminals on input side of circuit breaker directly feeding each individual drive.
- C. Total Harmonic Distortion (THD) at each PCC shall not exceed 5%, as recommended for General Systems as listed in Table 10.2 of IEEE Standard 519.
- D. Harmonic current distortion at PCC shall not exceed limits listed in Table 10.3 of IEEE Standard 519.
- E. Design drive to provide 50,000 hours mean time between failures (MTBF) when specified preventative maintenance is performed.
- F. Design motors furnished to meet NEMA MG1, Part 31 for VFD service.
- G. Symbols shall conform to ANSI Y32.2/IEEE 315/CSA Z99.
- H. Printed circuit boards shall be completely tested and burned-in, in accordance with UL347A before being assembled into completed VFD.

#### 2.04 INPUT POWER

- A. System shall be capable of maintaining rated torque and speed with bus voltage deviations of  $\pm 10\%$  and frequency deviations of  $\pm 5\%$ .
- B. Line notching, transients, and harmonics on incoming line shall not affect VFD performance.
- C. Below 70% bus voltage, motor will be allowed to coast. If bus voltage is restored within 2 seconds, system can be started, if selected. If bus voltage is not restored within 2 seconds, system shall be automatically shut down. Automatic or manual restart shall be selectable from control panel.
- D. VFD shall have provisions for input line reactor to be incorporated into VFD enclosure.
- E. Drive efficiency shall be 95% or higher at rated load.

#### 2.05 OUTPUT POWER

- A. Operating mode:
  - 1. Frequency at 60 Hz and below: Constant volts per Hz mode.
  - 2. Above 60 Hz: Selectively operate in either constant volts per Hz mode or constant voltage extended frequency mode.
- B. Rated output voltage: Programmable for either 80 to 240 volts or from 320 to 480 volts depending on 3-phase motor nameplate rating.
- C. VFD shall be capable of minimum of 110% of rated full-load current in continuous operation, in accordance with NEC Table 430.150.

#### 2.06 OPERATING RANGE

- A. Speed range: 6 to 60 Hz. Both minimum and maximum speeds shall be field-adjustable.
- B. VFD shall not have electrical resonance within operating speed range.

- C. VFD shall be able to speed search and immediately pick up spinning motor in either forward or reverse direction.

## 2.07 TORSIONAL REQUIREMENTS

- A. VFD, motor, and equipment load shall not develop adverse speed dependent oscillations.

## 2.08 NOISE

- A. Drive shall not cause motor audible noise to increase more than 3 dB at 3' (1 m) above rated noise level for operation on full voltage starter.

## 2.09 MINIMUM DISPLACEMENT POWER FACTOR

- A. PF 0.90 lagging, or higher, at any speed or load without use of power factor correction capacitors.

## 2.10 HARMONICS MITIGATION

- A. Provide output filters, as required, such that motor insulation will not be damaged.
- B. If additional equipment is necessary to meet IEEE 519 requirements, it shall be through use of one or more of following:
  1. Input isolation transformer.
  2. Input line reactor.
  3. Input harmonic trap filter with series reactor.
  4. Higher pulse rectifier.
  5. Mirus filter.
  6. Dc link reactor.
- C. Drive manufacturer shall select and approve equipment provided.

## 2.11 DRIVE CONTROL

- A. VFD shall use control strategy that maximizes efficiency, performance, and power factor while minimizing motor heating.
- B. Drive regulator and control: Digital microprocessor design with following functions:
  1. Speed regulation.
  2. Current regulation.
  3. Load angle regulation.
  4. Drive protection.
  5. Drive diagnostics.
  6. System sequencing.
- C. VFD regulator and control functions shall be stored on nonvolatile memory.
- D. Drive shall have minimum of 3 programmable prohibited frequency ranges with adjustable span of 0 to 10 Hz.
- E. Provide drive with local and remote controls:
  1. Locate 2-position maintained switch on front of enclosure for selection of "Local" or "Remote" control.
  2. Individual momentary buttons for "Local," "Start," and "Stop."
  3. Speed reference potentiometer.
- F. Operation:

1. Switch in "Local" position: Drive shall operate at speed set by potentiometer when local "Start" button is pushed. "Stop" button shall stop equipment without delay.
  2. Switch in "Remote" position: Drive shall be remotely controlled. Local potentiometer, "Start" button, and "Stop" button shall have no effect on operation.
    - a. Speed control shall regulate motor speed corresponding to remote speed signal.
    - b. When incoming signal is varying, rate of change of motor speed shall be limited by pre-selected acceleration/ deceleration rate.
    - c. Drive shall be programmable to either run at constant speed as determined by minimum speed setting, last signal, preset speed, or to shut down, upon loss of speed signal. Remote speed signal falling below lower limit of range shall also be considered as loss of speed signal. Loss of remote speed signal shall be alarmed.
    - d. If remote speed signal is above range upper limit, drive shall run at speed corresponding to upper limit.
    - e. Alarms and indication:
      - 1) Loss of remote speed signal shall be alarmed.
      - 2) Drive failure alarm.
      - 3) Drive fault alarm.
      - 4) Drive in remote and local control indication.
      - 5) Drive running indication.
- G. Following shall be available locally either on control panel display or by use of readouts and LEDs, and remotely through communication interface:
1. Drive ready.
  2. Drive running.
  3. Current, amps.
  4. Line-line voltage, volts.
  5. Output horsepower, hp.
  6. Speed, rpm.
  7. Frequency, Hz: Digital readout.
  8. Drive alarm conditions.
    - a. Missing run or start permissive.
    - b. Low control voltage.
    - c. Microprocessor problem.
    - d. I/O addressing problem.
    - e. Loss of speed reference.
    - f. Common trouble alarm.
  9. Drive fault conditions requiring immediate attention, and may indicate impending shutdown of drive.
    - a. Source undervoltage.
    - b. Source overvoltage.
    - c. Source loss of phase.
    - d. Source reverse phase sequence.
    - e. Load overcurrent.
    - f. Overspeed.
    - g. Ground fault.
    - h. Dc Link overvoltage.
- H. Provide communications interface for remote monitoring and control of VFD using DeviceNet communications protocol.

## 2.12 DRIVE DIAGNOSTICS

- A. Provide comprehensive diagnostics for maintenance and troubleshooting including:
1. Self-test of microprocessor drive control system.
  2. LED indicators for status indication on control boards.
  3. Convenient maintenance test points.

## 2.13 COOLING

- A. Provide integral filtered ambient air cooling by natural convection or forced air cooling system as required to maintain drive equipment at its full current rating.

#### 2.14 IDENTIFICATION AND TAGGING

- A. Securely attach nameplates with self-tapping stainless steel screws. Adhesive nameplates not acceptable.
- B. Lettering shall be black on white background.

### **PART 3 EXECUTION**

#### 3.01 PREPARATION

- A. Clean interior and exterior of equipment prior to placing into service. Debris shall be removed and appropriately discarded.

#### 3.02 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Perform manufacturer's recommended start-up and commissioning tests prior to placing into service.
- C. Correct deficiencies with VFD and other furnished equipment until system operates as required for installed equipment, at no cost to Owner.
- D. Refinish marred spots to match original finish.

<b>DATA SHEETS</b> <b>LOW VOLTAGE VFD</b>		Equipment Name: AH-1 Supply Fan VFD	
		Tag No.: VFD1	REV. #
DESCRIPTION	UNITS/ OPTIONS	SPEC DATA	VENDOR DATA
Manufacturer	N/a		
Catalog/Serial No.	N/a		
<b>General:</b>			
Driven Equipment	-		
Motor NEMA Design	NEMA	Design B	
Nominal Operating Voltage	V	480V	
System Operating Frequency	Hz	60Hz	
Motor Nameplate Voltage	V	460V	
Motor Nameplate Horsepower	Hp	40 HP	
<b>Cable information:</b>			
Power Cable Incoming Location	Top/Bottom		
Power Cable Exit Location	Top/Bottom		
Maximum Expected Cable Length	ft	40	
<b>Site information:</b>			
Maximum Ambient Temperature	°C	40	
Minimum Ambient Temperature	°C	-20	
<b>Design:</b>			
Rectifier Type	-	PWM	
No of Pulses, Minimum	12, 18, or 24	18	
THD at Point of Common Coupling (PCC)	%	5%	
Available Short Circuit Current at PCC	kA	65	
Mean Time Between Failure (MTFB), Minimum	Hrs	50,000	
Maximum Input Voltage Variation	%	+/- 10	
Maximum Input Frequency Variation	%	+/- 5	
Drive Efficiency, Minimum	%	95	
Displacement Power Factor, minimum	pu	0.9	
Programmable Output Voltage Range	V -V	320 – 480	
Overvoltage Capability of System Voltage, Min.	%	110	
Speed Range	Hz -Hz	6 – 60	
Minimum Programmable Prohibited Freq. Ranges	Qty	3	
Prohibited Freq. Range Span	Hz - Hz	0 – 10	
<b>Enclosure:</b>			
NEMA Rating	NEMA	1	
Dimensions	L x W x H	By Manufacturer	
Weight	lbs	By Manufacturer	
Cooling Method	Air/Water	By Manufacturer	
<b>Controls:</b>			
Local /Remote Switch	Y/N	Y	
Start and Stop Push Buttons	Y/N	Y	
Local Speed Reference Potentiometer/Adjustment	Y/N	Y	
Programmable Speed Setting	Y/N	Y	
Local LCD or LED Readout Panel	Y/N	Y	
Local and Remote Alarm Indication	Y/N	Y	
Monitoring of VFD Fault Conditions	Y/N	Y	
Communication Interface	-	DeviceNet	
<b>Accessories:</b>			

<b>DATA SHEETS LOW VOLTAGE VFD</b>		<b>Equipment Name: AH-1 Supply Fan VFD</b>	
		<b>Tag No.: VFD1</b>	<b>REV. #</b>
<b>DESCRIPTION</b>	<b>UNITS/ OPTIONS</b>	<b>SPEC DATA</b>	<b>VENDOR DATA</b>
Input Isolation Transformer	Y/N	By Manufacturer	
Input Line Reactor	Y/N	By Manufacturer	
Input Harmonic Filter Trap with Series Reactor	Y/N	By Manufacturer	
Output Filter	Y/N	By Manufacturer	
Mirus Filter	Y/N	By Manufacturer	
DC Link Reactor	Y/N	By Manufacturer	
Special Accessories Required:	Y/N	By Manufacturer	

<b>DATA SHEETS</b> <b>LOW VOLTAGE VFD</b>		Equipment Name: VFD for 15 HP motors	
		Tag No.: VFD2,3,4	REV. #
DESCRIPTION	UNITS/ OPTIONS	SPEC DATA	VENDOR DATA
Manufacturer	N/a		
Catalog/Serial No.	N/a		
<b>General:</b>			
Driven Equipment	-		
Motor NEMA Design	NEMA	Design B	
Nominal Operating Voltage	V	480V	
System Operating Frequency	Hz	60Hz	
Motor Nameplate Voltage	V	460V	
Motor Nameplate Horsepower	Hp	15 HP	
<b>Cable information:</b>			
Power Cable Incoming Location	Top/Bottom		
Power Cable Exit Location	Top/Bottom		
Maximum Expected Cable Length	ft	40	
<b>Site information:</b>			
Maximum Ambient Temperature	°C	40	
Minimum Ambient Temperature	°C	-20	
<b>Design:</b>			
Rectifier Type	-	PWM	
No of Pulses, Minimum	12, 18, or 24	18	
THD at Point of Common Coupling (PCC)	%	5%	
Available Short Circuit Current at PCC	kA	65	
Mean Time Between Failure (MTFB), Minimum	Hrs	50,000	
Maximum Input Voltage Variation	%	+/- 10	
Maximum Input Frequency Variation	%	+/- 5	
Drive Efficiency, Minimum	%	95	
Displacement Power Factor, minimum	pu	0.9	
Programmable Output Voltage Range	V -V	320 – 480	
Overvoltage Capability of System Voltage, Min.	%	110	
Speed Range	Hz -Hz	6 – 60	
Minimum Programmable Prohibited Freq. Ranges	Qty	3	
Prohibited Freq. Range Span	Hz - Hz	0 – 10	
<b>Enclosure:</b>			
NEMA Rating	NEMA	1	
Dimensions	L x W x H	By Manufacturer	
Weight	lbs	By Manufacturer	
Cooling Method	Air/Water	By Manufacturer	
<b>Controls:</b>			
Local /Remote Switch	Y/N	Y	
Start and Stop Push Buttons	Y/N	Y	
Local Speed Reference Potentiometer/Adjustment	Y/N	Y	
Programmable Speed Setting	Y/N	Y	
Local LCD or LED Readout Panel	Y/N	Y	
Local and Remote Alarm Indication	Y/N	Y	
Monitoring of VFD Fault Conditions	Y/N	Y	

<b>DATA SHEETS</b> <b>LOW VOLTAGE VFD</b>		<b>Equipment Name: VFD for 15 HP motors</b>	
		<b>Tag No.: VFD2,3,4</b>	<b>REV. #</b>
<b>DESCRIPTION</b>	<b>UNITS/ OPTIONS</b>	<b>SPEC DATA</b>	<b>VENDOR DATA</b>
Communication Interface	-	DeviceNet	
<b>Accessories:</b>			
Input Isolation Transformer	Y/N	By Manufacturer	
Input Line Reactor	Y/N	By Manufacturer	
Input Harmonic Filter Trap with Series Reactor	Y/N	By Manufacturer	
Output Filter	Y/N	By Manufacturer	
Mirus Filter	Y/N	By Manufacturer	
DC Link Reactor	Y/N	By Manufacturer	
Special Accessories Required:	Y/N	By Manufacturer	

<b>DATA SHEETS</b> <b>LOW VOLTAGE VFD</b>		Equipment Name: VFD for 7.5 HP motors	
		Tag No.: VFD5,6,7,8 REV. #	
DESCRIPTION	UNITS/ OPTIONS	SPEC DATA	VENDOR DATA
Manufacturer	N/a		
Catalog/Serial No.	N/a		
<b>General:</b>			
Driven Equipment	-		
Motor NEMA Design	NEMA	Design B	
Nominal Operating Voltage	V	480V	
System Operating Frequency	Hz	60Hz	
Motor Nameplate Voltage	V	460V	
Motor Nameplate Horsepower	Hp	7.5 HP	
<b>Cable information:</b>			
Power Cable Incoming Location	Top/Bottom		
Power Cable Exit Location	Top/Bottom		
Maximum Expected Cable Length	ft	40	
<b>Site information:</b>			
Maximum Ambient Temperature	°C	40	
Minimum Ambient Temperature	°C	-20	
<b>Design:</b>			
Rectifier Type	-	PWM	
No of Pulses, Minimum	12, 18, or 24	18	
THD at Point of Common Coupling (PCC)	%	5%	
Available Short Circuit Current at PCC	kA	65	
Mean Time Between Failure (MTFB), Minimum	Hrs	50,000	
Maximum Input Voltage Variation	%	+/- 10	
Maximum Input Frequency Variation	%	+/- 5	
Drive Efficiency, Minimum	%	95	
Displacement Power Factor, minimum	pu	0.9	
Programmable Output Voltage Range	V -V	320 – 480	
Overvoltage Capability of System Voltage, Min.	%	110	
Speed Range	Hz -Hz	6 – 60	
Minimum Programmable Prohibited Freq. Ranges	Qty	3	
Prohibited Freq. Range Span	Hz - Hz	0 – 10	
<b>Enclosure:</b>			
NEMA Rating	NEMA	1	
Dimensions	L x W x H	By Manufacturer	
Weight	lbs	By Manufacturer	
Cooling Method	Air/Water	By Manufacturer	
<b>Controls:</b>			
Local /Remote Switch	Y/N	Y	
Start and Stop Push Buttons	Y/N	Y	
Local Speed Reference Potentiometer/Adjustment	Y/N	Y	
Programmable Speed Setting	Y/N	Y	
Local LCD or LED Readout Panel	Y/N	Y	
Local and Remote Alarm Indication	Y/N	Y	
Monitoring of VFD Fault Conditions	Y/N	Y	
Communication Interface	-	DeviceNet	

<b>DATA SHEETS</b> <b>LOW VOLTAGE VFD</b>		<b>Equipment Name: VFD for 7.5 HP motors</b>	
		<b>Tag No.: VFD5,6,7,8 REV. #</b>	
<b>DESCRIPTION</b>	<b>UNITS/ OPTIONS</b>	<b>SPEC DATA</b>	<b>VENDOR DATA</b>
<b>Accessories:</b>			
Input Isolation Transformer	Y/N	By Manufacturer	
Input Line Reactor	Y/N	By Manufacturer	
Input Harmonic Filter Trap with Series Reactor	Y/N	By Manufacturer	
Output Filter	Y/N	By Manufacturer	
Mirus Filter	Y/N	By Manufacturer	
DC Link Reactor	Y/N	By Manufacturer	
Special Accessories Required:	Y/N	By Manufacturer	

END OF SECTION

- 1) LD Vance
- 2)

**PART 1 GENERAL**

## 1.01 SECTION INCLUDES

- A. Interior lighting fixtures and accessories.
- B. Ballasts.
- C. Light control systems.
- D. Emergency lighting systems.

## 1.02 ACTION SUBMITTALS

- A. Product Data:
  - 1. Lamp ANSI designation, initial and mean lumen output, average rated hours of lamp life and lamp mortality curve, and color temperature and color rendering index.
  - 2. Ballast ANSI designation; electrical characteristics, including volts, lamp, and line operating and starting amperes, watts and watt losses, percent of allowable line voltage variation range and lamp crest factor; total current harmonic distortion; minimum lamp starting temperature; and normal and maximum ballast operating temperature.
- B. Shop Drawings: Dimensioned and detailed drawings in booklet form with separate sheet or sheets for each fixture, assembled in luminaire "type" alphabetical order and showing:
  - 1. Materials of construction.
  - 2. Arrangement of components and wiring.
  - 3. Gasket sealed for weather tightness.
  - 4. Means of mounting luminaire and adjusting aspect.
  - 5. Finish; photometric data with lamp or lamps specified.
  - 6. Electrical data including volts, amperes and watts.

## 1.03 QUALITY ASSURANCE

- A. Manufacturer qualifications:
  - 1. Manufacturer of major components within assembly.
  - 2. ISO 9000 certified.
  - 3. Manufacturer shall have produced similar electrical equipment for a minimum period of 5 years.
  - 4. When requested by Engineer, provide acceptable list of similar equipment installations complying with requirements of this specification.
- B. American National Standards Institute (ANSI)
  - 1. ANSI C82.1 - Ballasts for Fluorescent Lamps.
  - 2. ANSI C82.2 - Fluorescent Lamp Ballasts - Methods of Measurement.
  - 3. ANSI C82.4 - Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps.
  - 4. ANSI C2 - National Electrical Safety Code.
  - 5. ANSI C81.10-76 - Electric Lamp Bases and Holders - Screw-Shell Types (Revised and Consolidated into ANSI C81.61-90).
  - 6. ANSI C82.1 - Specifications for Fluorescent Lamp Ballasts.
- C. Federal Communications Commission (FCC) Part 15 - Rules and Regulations: Radio Frequency Devices
- D. National Electrical Manufacturers Association (NEMA)
  - 1. 270 - Procedure for Fluorescent Lamp/Ballast/Fixture Performance Comparison.
  - 2. OD 3 - Physical and Electrical Interchangeability of Photo Control Devices and Mating Receptacles.

- E. National Fire Protection Association (NFPA):
  - 1. 70 - National Electrical Code (NEC)
  - 2. 90A - Installation of Air Conditioning and Ventilation Systems.
  - 3. 101 - Code for Safety to life from fire in Buildings and Structures.
  
- F. Underwriters Laboratories (UL):
  - 1. UL 57 - Electric Fixture.
  - 2. UL 496 - Edison-Base Lamp holders.
  - 3. UL 676 - Underwater Lighting Fixtures.
  - 4. UL 542 - Lamp holders, Starters, and Starter Holders for Fluorescent Lamps.
  - 5. UL 773 - Plug-in, Locking Type Photo controls, for Use with Area Lighting.
  - 6. UL 773A - Non-industrial Photoelectric Switches for Lighting Control.
  - 7. UL 884 - Lighting fixtures used in hazardous locations.
  - 8. UL 935 - Fluorescent Lamp Ballasts.
  - 9. UL 1570 - Fluorescent Lighting Fixtures.
  - 10. UL 1571 - Incandescent Lighting Fixtures.
  
- G. Code of Federal Regulations (CFR):
  - 1. CFR 21 Part 1040 - Performance Standards for Light-Emitting Products.
  - 2. CFR 40 Part 761 - Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.
  
- H. Federal Specifications (FS) W-F-412E - Fixtures, Lighting, Incandescent Lamp Industrial.
  
- I. Illuminating Engineering Society of North America (IES), LHBK - Lighting Handbook, References and Application Volumes.

#### 1.04 DELIVERY, STORAGE, AND HANDLING

- A. During delivery and storage, handle equipment to prevent damage, denting, or scoring.
- B. Store equipment and components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer's instructions.

## **PART 2 PRODUCTS**

#### 2.01 LIGHTING FIXTURES

- A. Types: As designated in "Lighting Fixture Schedule" on Drawings.
- B. Lighting fixtures shall be furnished completely assembled with wiring and mounting devices, ready for installation in their intended location.
- C. Design fixtures with supports independent of ceiling supports.
- D. Equip with required lamps.
- E. Fixtures used as air handling registers shall meet requirements for intended use.
- F. Fluorescent lamp sockets:
  - 1. Lamp holder contacts: Biting-edge type of phosphorous-bronze with silver flash contact surface type.
  - 2. Contacts for recessed, double-contact lamp holders and for slim line lamp holders: Silver-plated.
  - 3. Lamp holders for bi-pin lamps, except for "U" type lamps: Telescoping-compression type, or single-slot entry type requiring 1/4 turn of lamp after insertion.
- G. Incandescent and HID shall have porcelain enclosures.

- H. Recessed fixtures mounted in insulated or fire rated ceiling shall be listed for use in insulated or fire rated ceilings.
- I. Lenses, diffusers, covers, and globes: 100% virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
  - 1. Plastic: High-resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
  - 2. Lens thickness: 0.125" (3 mm) minimum, unless greater thickness is indicated.

## 2.02 LAMPS

- A. Comply with standard of ANSI C78 series that is applicable to each type of lamp. Provide luminaires with indicated lamps of designated type, characteristics, and wattage. Where a lamp is not indicated for a luminaire, provide medium wattage lamp recommended by manufacturer for luminaire.
- B. Fluorescent color temperature and minimum color-rendering index: 3500 K and 85 CRI, unless otherwise indicated.

## 2.03 LIGHTING BALLASTS

- A. Fluorescent lamp ballasts shall be suitable for lamps as listed in "Lighting Fixture Schedule" and as follows:
- B. Fluorescent, solid-state, electronic ballast "Solid-State Ballast":
  - 1. Type: Rapid start mode.
  - 2. Thermal protection: UL Class P with internal automatic-resetting.
  - 3. Conform to ETL-CBM label requirements.
  - 4. Power factor: Not less than 90%.
  - 5. Maintain constant light output of 4' rapid-start fluorescent lamps over operating ranges of 90 volts to 145 volts (120-volt ballasts) and 200 volts to 320 volts (277-volt ballasts).
  - 6. Input current third harmonic content: Not to exceed 13%.
  - 7. Total current THD: Less than 20%.
  - 8. Provide sequenced start progression which first heats cathode filaments and then ignites lamp.
  - 9. Withstand line transients: As defined in IEEE Publication 587, Category A.
  - 10. Frequency of operation: 20 kHz or greater, and operate without visible flicker.
  - 11. Meet requirements of Federal Communications Commission Rules and Regulations, Part 18.
  - 12. Parallel lamp circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.
  - 13. Ballast:
    - a. Light regulation of  $\pm 10$  lumen output with  $\pm 10\%$  input voltage regulation. Ballast shall have 10% flicker (maximum) using any compatible lamp.
    - b. UL-listed Class P with a sound rating of "A."
    - c. Enclosure size shall conform to standards of electromagnetic ballasts.
    - d. Ballast shall have circuit diagrams and lamp connections displayed on ballast packages.
    - e. Ballast shall operate lamps in a parallel circuit configuration that permits operation of remaining lamps if one or more lamps fail or are removed.
  - 14. T-8 lamp ballast:
    - a. Ballast shall be capable of starting and maintaining operation at a minimum of 50°F (10°C) for F32T8 lamps, unless otherwise indicated. When indicated, ballast shall be capable of starting and maintaining operation at a minimum of 0°F (-17°C) for F32T8 lamps.
    - b. Total harmonic distortion (THD): 20% (maximum). Input wattage:
      - 1) 32 watts (maximum) when operating one F32T8 lamp.
      - 2) 62 watts (maximum) when operating two F32T8 lamps
      - 3) 92 watts (maximum) when operating three F32T8 lamps
      - 4) 114 watts (maximum) when operating four F32T8 lamps
    - c. Provide 3 and 4 lamp fixtures with 2 ballasts per fixture where multilevel switching is indicated.
  - 15. F17T8 lamp ballast:

- a. Capable of starting maintaining operation at a minimum of 50°F (10°C) for F17T8 lamps, unless otherwise indicated.
  - b. Total harmonic distortion (THD): 25% (maximum).
  - c. Input wattage: 34 watts (maximum) when operating two F17T8 lamps.
16. T-5 long twin tube lamp ballast:
- a. Minimum starting temperature: 50°F (10°C).
  - b. Total harmonic distortion (THD): Not greater than 25% when operating one lamp, 15% when operating 2 lamps.
  - c. Input wattage:
    - 1) 45 watts (maximum) when operating one F40 T-5 lamp.
    - 2) 74 watts (maximum) when operating two F40 T-5 lamps.
    - 3) 105 watts (maximum) when operating three F40 T-5 lamps.
  - d. Provide 3 and 4 lamp fixtures with 2 ballasts per fixture where multilevel switching is indicated.
- C. Fluorescent lamp electronic dimming ballast:
1. Ballast shall comply with UL 935, IEEE C62.11, and NFPA 70, unless specified otherwise.
  2. Dimming capability range: 100% to 20% (minimum range) of light output, flicker free.
  3. Ballast shall start lamp at any preset light output setting. \*When power is applied, ballast shall not ramp up to full light output and then dim to preset level.\*
  4. Design for wattage of lamps used in indicated application. Design to operate on voltage system to which they are connected.
  5. Power factor: 0.95 (minimum) at full light output; 0.90 (minimum) over entire dimming range.
  6. Ballast shall operate at a frequency of 20,000 Hz (minimum).
  7. Ballast factor at full light output shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).
  8. UL-listed Class P with a sound rating of "A".
  9. Display circuit diagrams and lamp connections on ballast. Ballast shall operate lamps in parallel circuit configuration that permits operation of remaining lamps if one or more lamps fail or are removed.
  10. Ballast shall operate in a rapid start mode.
  11. Ballast shall be capable of starting and maintaining operation at a minimum of 50°F (10°C) for F32T8 lamps, unless otherwise indicated.
  12. Total harmonic distortion (THD): 20% (maximum) over entire dimming range.
  13. T-8 lamp ballast input wattage, for indicated lamp quantity:
    - a. 35 watts (maximum) when operating one F32T8 lamp.
    - b. 70 watts (maximum) when operating two F32T8 lamps.
    - c. 104 watts (maximum) when operating three F32T8 lamps.
- D. Dimming ballast controls: Slide dimmer with on/off control, compatible with ballast and control ballast light output over full dimming range.
- E. Light level sensor:
1. UL-listed.
  2. Capable of detecting changes in ambient lighting levels
  3. Dimming range of 20% to 100%, minimum.
  4. Design for use with dimming ballast and voltage system to which they are connected.
  5. Capable of controlling 40 electronic dimming ballast, minimum.
  6. Light level shall be adjustable and have a set level range from 10 to 100 foot-candles 100 to 1000 lux, minimum.
  7. Provide bypass function to electrically override sensor control.
- F. Fluorescent electromagnetic ballasts:
1. UL 935. Ballasts shall be high power factor type (0.9 minimum), unless indicated otherwise and designed to operate on voltage system to which they are connected.
  2. Ballasts shall be Class P and shall have sound rating "A" unless otherwise noted.
  3. Design and construct fixtures and ballasts to limit ballast case temperature to 90°C when installed in an ambient temperature of 40°C.

4. Electromagnetic ballasts for T-8 and T-12 lamps shall be energy saving.
  5. Provide 3 lamp fixtures with 2 ballasts per fixture.
  6. Electromagnetic energy-saving ballasts:
    - a. NEMA C82.1. Provide energy-saving fluorescent ballasts of CBM certified full light output type.
    - b. Provide ballasts which are compatible with energy-saving lamps.
  7. Provide electromagnetic ballasts for compact fluorescent lamps.
- G. Maximum sound ratings (equivalent to General Electric ratings):
1. Rapid-start: Sound Level A.
  2. Instant-start (Slim line): Sound Level C.
  3. High-output (800 mA): Sound Level C.
  4. Super-high-output (1,500 mA): Sound Level D.
- H. Standards: ANSI C82.1 and UL 935.
- I. Luminaire wiring:
1. Conductors: Stranded copper.
  2. Insulation: 600-volt class, type in accordance with manufacturer's standards for ambient and environmental conditions.
  3. Other requirements in accordance with NEC Article 410F.

#### 2.04 RECESS- AND FLUSH-MOUNTED FIXTURES

- A. Provide fixture type that can be re-lamped from bottom. Access to ballast shall be from bottom.
- B. Trim for exposed surface of flush-mounted fixtures shall be as indicated.

#### 2.05 SUSPENDED FIXTURES

- A. Hangers:
  1. Provide hangers capable of supporting twice combined weight of fixtures supported by hangers.
  2. Type: Cadmium-plated steel with swivel-ball tapped for conduit size indicated.
  3. Hangers shall allow fixtures to swing within an angle of 0.79 rad 45°.
- B. Single-unit suspended fluorescent fixtures shall have twin-stem hangers.
- C. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and tubing or rod suspension provided for each unit length of chassis, including one at each end.
- D. Rods shall be a minimum 0.18" (4.57 mm) diameter.

#### 2.06 EMERGENCY LIGHTING UNITS

- A. UL-listed, self-contained battery-powered units that automatically turn on lights upon ac power failure and turn off lights upon restoration of service.
- B. Sign colors and lettering size: Comply with authorities having jurisdiction.
- C. Battery:
  1. Type: Lead-acid, sealed lead-calcium, or nickel-cadmium rechargeable, sealed, maintenance-free with 5-year warranty.
  2. Voltage: 6 volts or 12 volts.
  3. Capacity: Capable of operating unit for 90 minutes following power failure.
- D. Battery charger and switching circuits shall be of solid-state type for use on 115-volt ac supply.
- E. Lamps: 2 sealed-beam halogen-type, mounted on unit.

- F. Suitable for use in ambient temperatures of 50°C.
- G. Accessories:
  - 1. Test switch for testing lamps and battery.
  - 2. Pilot light: Indicates that unit is connected to live ac supply.
  - 3. Rubber cord and plug.
- H. Provide complete with mounting hardware.
- I. Exit signs:
  - 1. Self-powered LED-type (battery backup):
    - a. Provide with automatic power failure device, \*test switch, pilot light, and fully automatic high/low trickle charger in a self-contained power pack.
    - b. Battery: Sealed electrolyte type, operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years.
    - c. LED exit sign shall have emergency run time of 1-1/2 hours (minimum).
    - d. LEDs shall have rated lamp life of 70,000 hours (minimum).
  - 2. Remote-powered:
    - a. Provide remote ac/dc signs with provisions for wiring to external ac and dc power sources.
    - b. Provide signs with minimum of 2 ac lamps for normal illumination and a minimum of 2 dc lamps for emergency lighting.

## 2.07 LIGHTING CONTROLS

- A. Contactor, electrically-held, nonlatching type:
  - 1. Ratings:
    - a. Continuous current: As shown on Drawings.
    - b. Contacts: 277 volts.
    - c. Coil: 277 volts.
    - d. Frequency: 60 Hz.
  - 2. Accessories:
    - a. Control transformer rated 277 volts.
    - b. "Hand-Off-Auto" selector switch on contactor cover.
  - 3. Enclosures: NEMA 12.
  - 4. Control: Photocell.
  - 5. Manufacturer: Allen-Bradley Bulletin 500L, General Electric CR160L, Square D Class 8903.
- B. Photocell controls :
  - 1. Type: Locking; approved sealed cadmium-sulfide cell.
  - 2. Ratings: 277 volts, 60 Hz, 1,800 VA.
  - 3. Contacts: Single-pole for control of mechanically held contactors arranged to fail in on position
  - 4. Switching range:
    - a. On: 1 footcandle.
    - b. Off: 4.5 to 10 footcandles with 15-second minimum time delay
  - 5. Minimum time delay on turn-off: 15 seconds.
  - 6. Temperature range: -10°C to 50°C.
  - 7. Enclosure: Weatherproof (integral to fixture).
  - 8. Mounting: Locking-type receptacle.
  - 9. Manufacturer: As shown on Drawings or Precision Multiple Controls, Inc. "Lumatrol T-15," Paragon "CW Series," Fisher-Pierce "7700" series.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Examine each piece of equipment to ensure there are no defects and that equipment conforms to these specifications.

### 3.02 PREPARATION

- A. Interior and exterior of equipment shall be cleaned prior to placing into service. Debris shall be removed and appropriately discarded.

### 3.03 INSTALLATION

- A. Install equipment in strict accordance with manufacturer's recommendations.
- B. Determine locations and arrangement of equipment from Drawings. Locations shown on Drawings are approximate unless dimensioned. Choose precise location to clear obstructions and to provide sufficient space for operation and maintenance.
- C. Coordinate timing of installation and location of equipment with other trades.
- D. Make permanent lighting system, or selected portions thereof, operable as soon as possible.
- E. Perform construction in accordance with NEC.
- F. Repair factory finishes where they become damaged during construction.
- G. Install equipment level and plumb.
- H. Coordinate with Division 1 for temporary lighting during construction.
- I. Grounding:
  - 1. Ground noncurrent carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures.
  - 2. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.
- J. Lighting fixtures:
  - 1. Support lighting fixtures from building framing or floor slabs, independent of conduit system and suspended ceilings.
  - 2. To minimize equipment breakage, delay installation of lighting fixtures in locations near heavy piping and equipment until such equipment is in place.
  - 3. When permanent lighting system becomes operable, re-lamp lighting fixtures, as directed by Owner.
  - 4. Replace defective or damaged lighting fixtures and lamps at conclusion of job.
- K. Wall-mounted equipment:
  - 1. Concrete or masonry walls: Use expansion anchors and bolts; install collars around mounting bolts, or use other means to provide air space between wall and equipment enclosure.
  - 2. Structural steel mounting: Bolt to steel or brackets attached to steel; provide air space between steel and equipment enclosure.
- L. Floor-mounted equipment: Secure to concrete floor or foundation with expansion anchors.
- M. Emergency lighting system: Install raceway and wiring for emergency lighting system in accordance with NEC Article 700.
- N. Lighting controls:
  - 1. Mount photocells facing north or upward and adjust to render insensitive to artificial lighting units.
  - 2. Install occupancy sensors and ambient light sensor in accordance with manufacturer's installation procedures. Final adjustments of sensors shall be coordinated with Owner for proper settings.

END OF SECTION

- 1) LDV
- 2)