CALIFORNIA STATE UNIVERSITY, BAKERSFIELD

ART CENTER AND SATELLITE COOLING PLANT

PRELIMINARY DESIGN #2
JULY 2008

TECHNICAL SPECIFICATIONS

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# TABLE OF CONTENTS

## DIVISION 02 – SITE CONSTRUCTION

- 02015 Site Utility Locator Requirements
- 02200 Site Preparation and Earthwork
- 02210 Geotechnical Data
- 02300 Earthwork
- 02510 Asphalt Concrete Paving
- 02520 Site Concrete Work
- 02621 Foundation Drainage
- 02660 Water Distribution System
- 02720 Storm Drains
- 02730 Sanitary Sewers
- 02751 Concrete Pavement

## DIVISION 03 – CONCRETE

- 03100 Concrete Formwork
- 03200 Concrete Reinforcement
- 03300 Cast In Place Concrete

## DIVISION 04 – MASONRY

- 04220 Concrete Unit Masonry

## DIVISION 05 – METALS

- 05129 Structural Steel
- 05300 Metal Decking
- 05500 Metal Fabrications

## DIVISION 06 – WOOD AND PLASTICS

- 06100 Rough Carpentry
- 06112 Wood Framing and Sheathing
- 06114 Wood Backing Blocking and Curbing
- 06174 Wood I-Joists
- 06181 Glue Laminated Structural Units
- 06402 Interior Architectural Woodwork
# Table of Contents

**ART CENTER AND SATELLITE COOLING PLANT**
**CALIFORNIA STATE UNIVERSITY, BAKERSFIELD**
**BAKERSFIELD, CA**

**DIVISION 07 – THERMAL AND MOISTURE PROTECTION**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>07210</td>
<td>Building Insulation</td>
</tr>
<tr>
<td>07411</td>
<td>Metal Roof Panels</td>
</tr>
<tr>
<td>07412</td>
<td>Metal Wall Panels</td>
</tr>
<tr>
<td>07430</td>
<td>Composite Aluminum Panel System</td>
</tr>
<tr>
<td>07450</td>
<td>Fiber Reinforced Cement Siding</td>
</tr>
<tr>
<td>07620</td>
<td>Sheet Metal Flashing and Trim</td>
</tr>
<tr>
<td>07720</td>
<td>Roof Accessories</td>
</tr>
<tr>
<td>07840</td>
<td>Through Penetration Firestopping and Smoke Seals</td>
</tr>
<tr>
<td>07920</td>
<td>Joint Sealers</td>
</tr>
</tbody>
</table>

**DIVISION 08 – DOORS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08110</td>
<td>Hollow Metal Sheet Door Frames</td>
</tr>
<tr>
<td>08125</td>
<td>Finished Steel Door Frames</td>
</tr>
<tr>
<td>08211</td>
<td>Flush Wood Doors</td>
</tr>
<tr>
<td>08305</td>
<td>Access Doors and Panels</td>
</tr>
<tr>
<td>08361</td>
<td>Overhead Sectional Doors</td>
</tr>
<tr>
<td>08410</td>
<td>Aluminum Entrances and Storefronts</td>
</tr>
<tr>
<td>08710</td>
<td>Door Hardware</td>
</tr>
<tr>
<td>08800</td>
<td>Glass and Glazing</td>
</tr>
</tbody>
</table>

**DIVISION 09 – FINISHES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>09110</td>
<td>Light Gage Metal Framing</td>
</tr>
<tr>
<td>09250</td>
<td>Gypsum Board</td>
</tr>
<tr>
<td>09310</td>
<td>Ceramic Tile</td>
</tr>
<tr>
<td>09510</td>
<td>Acoustical Panel Ceilings</td>
</tr>
<tr>
<td>09650</td>
<td>Resilient Flooring</td>
</tr>
<tr>
<td>09680</td>
<td>Carpet</td>
</tr>
<tr>
<td>09910</td>
<td>Field Painting</td>
</tr>
</tbody>
</table>

**DIVISION 10 – SPECIALTIES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10101</td>
<td>Visible Display Surfaces</td>
</tr>
<tr>
<td>10155</td>
<td>Toilet Compartment</td>
</tr>
<tr>
<td>10801</td>
<td>Toilet Accessories</td>
</tr>
</tbody>
</table>
### DIVISION 15 - MECHANICAL

<table>
<thead>
<tr>
<th>15010</th>
<th>Basic Mechanical Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>15013</td>
<td>Field Engineering</td>
</tr>
<tr>
<td>15060</td>
<td>Pipe and Pipe Fittings - General</td>
</tr>
<tr>
<td>15061</td>
<td>Steel Pipe and Fittings</td>
</tr>
<tr>
<td>15066</td>
<td>Copper Piping</td>
</tr>
<tr>
<td>15068</td>
<td>Fiberglass Reinforced Plastic Piping</td>
</tr>
<tr>
<td>15070</td>
<td>Prefabricated Underground Piping</td>
</tr>
<tr>
<td>15101</td>
<td>Gate Valves</td>
</tr>
<tr>
<td>15102</td>
<td>Ball Valves</td>
</tr>
<tr>
<td>15103</td>
<td>Butterfly Valves</td>
</tr>
<tr>
<td>15108</td>
<td>Check Valves</td>
</tr>
<tr>
<td>15140</td>
<td>Supports and Anchors</td>
</tr>
<tr>
<td>15170</td>
<td>Electric Motors</td>
</tr>
<tr>
<td>15171</td>
<td>Variable Speed Drives</td>
</tr>
<tr>
<td>15190</td>
<td>Mechanical Identification</td>
</tr>
<tr>
<td>15250</td>
<td>Insulation for Exposed Piping &amp; Equipment</td>
</tr>
<tr>
<td>15290</td>
<td>Ductwork Insulation</td>
</tr>
<tr>
<td>15430</td>
<td>Plumbing Specialties</td>
</tr>
<tr>
<td>15440</td>
<td>Plumbing Fixtures</td>
</tr>
<tr>
<td>15515</td>
<td>Hydronic Specialties</td>
</tr>
<tr>
<td>15535</td>
<td>Vertical Inline Pumps</td>
</tr>
<tr>
<td>15545</td>
<td>Chemical Water Treatment</td>
</tr>
<tr>
<td>15548</td>
<td>Cooling Tower Cleaning System</td>
</tr>
<tr>
<td>15625</td>
<td>Centrifugal Chillers</td>
</tr>
<tr>
<td>15635</td>
<td>Refrigerant Monitoring System</td>
</tr>
<tr>
<td>15640</td>
<td>Cooling Towers</td>
</tr>
<tr>
<td>15780</td>
<td>Thermal Energy Storage Tank</td>
</tr>
<tr>
<td>15855</td>
<td>Air Handling Units</td>
</tr>
<tr>
<td>15870</td>
<td>Fans</td>
</tr>
<tr>
<td>15890</td>
<td>Ductwork</td>
</tr>
<tr>
<td>15910</td>
<td>Ductwork Accessories</td>
</tr>
<tr>
<td>15930</td>
<td>Air Terminal Units</td>
</tr>
<tr>
<td>15936</td>
<td>Air Inlets and Outlets</td>
</tr>
<tr>
<td>15975</td>
<td>Direct Digital Controls</td>
</tr>
<tr>
<td>15990</td>
<td>Testing, Adjusting and Balancing</td>
</tr>
</tbody>
</table>

### DIVISION 16 - ELECTRICAL

<table>
<thead>
<tr>
<th>16010</th>
<th>Electrical General Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>16030</td>
<td>Electrical Acceptance Testing</td>
</tr>
<tr>
<td>16050</td>
<td>Basic Material &amp; Methods</td>
</tr>
<tr>
<td>16122</td>
<td>Medium Voltage Cables</td>
</tr>
<tr>
<td>16170</td>
<td>Grounding &amp; Bonding</td>
</tr>
<tr>
<td>16180</td>
<td>Equipment Wiring System</td>
</tr>
<tr>
<td>16195</td>
<td>Electrical Identification</td>
</tr>
<tr>
<td>16322</td>
<td>Secondary Substation Transformers</td>
</tr>
<tr>
<td>16402</td>
<td>Underground Electrical Work</td>
</tr>
<tr>
<td>16429</td>
<td>Low Voltage Distribution Switchboard</td>
</tr>
<tr>
<td>16460</td>
<td>Dry Type Transformers</td>
</tr>
<tr>
<td>16510</td>
<td>Lighting</td>
</tr>
</tbody>
</table>
SECTION 02015 – SITE UTILITY LOCATOR REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. Provide all labor and materials necessary to locate and identify site utilities. The contractor shall employ the services of a professional utility locator contractor regularly engaged in the location and marking of underground utilities and ground water.

1.2 RELATED SECTIONS (INCLUDE BUT ARE NOT NECESSARILY LIMITED TO)

A. Summary of Work, Section 01010.
B. Site Field Engineering, Section 15013.

1.3 UTILITY LOCATOR QUALIFICATIONS AND EQUIPMENT

A. Qualifications
   1. The utility locator contractor shall have on staff a California licensed civil engineer experienced in this type of work and experienced project managers and utility survey technicians.

B. Equipment
   1. The site utility location equipment and instrumentation shall include and not necessarily be limited to the following:
      a. Electromagnetic utility locator instruments, radio frequency transmitters, antenna receivers, pipeline and cable detectors, ground penetrating radar, and other such devices necessary to accurately identify and locate the various types and sizes of the underground site utilities existing on campus.
      b. The existing underground site utilities on campus include and are not necessarily limited to steel pipe, iron pipe, copper pipe, concrete carriers, transite pipe, pipe/conduit, vitreous clay pipe, PVC and electrical and telecommunications duct banks both with and without concrete encasement.

1.4 UTILITY LOCATION REQUIREMENTS

A. The utility locator shall mark out all utilities in the proposed alignment and cover a width of 20 feet (centered on proposed utility). Identify on asphalt or PCC surfaces, with color-coding, painted identification of utilities.

B. Exploratory excavations (Pilot Trench): The Contractor shall excavate a “pilot trench” as indicated before excavation of a full width utility trench. Contractor shall exercise extreme caution to prevent damage to surrounding surface features and utilities.

C. If any structure or utility is damaged, take immediate action to ensure the safety of persons and property and immediately affect necessary repairs.

END OF SECTION 02015
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Division 1 apply to this Section. Provide and perform site preparation and earthwork, complete site clearing, excavation, filling, backfilling, and compaction, over excavation and placement of engineered fill below floor slabs and footings, imported fill material as required, subgrade preparation for on-grade concrete, gravel fill under floor slabs, rough grading in asphaltic concrete paving areas, control of surface and ground water, testing and inspection of work of this section, clean up and disposal.

1.2 QUALITY ASSURANCE

A. Professional Observation: Required for all work of this Section. The Soils Engineer shall have the following duties:
   1. Observe the stripping and clearing of vegetation and deleterious materials.
   2. Observe the over excavation to determine that the depth of excavation and bottom of the subgrade are suitable.
   3. Observe the exposed subgrade in areas to receive fill and in areas where excavation has resulted in the desired finished subgrade, observe proof rolling, and delineate areas requiring additional excavation.
   4. Observe the compaction of scarified soils.
   5. Perform visual observation to evaluate the suitability of on-site and imported soils for fill placement; collect and submit soil samples for laboratory testing.
   6. Perform field density and compaction testing to determine the percentage of compaction achieved during placement of fills.
   7. Observe and probe foundation bearing materials to confirm that suitable bearing materials are present at the design grades.
   8. Observe the backfill of utility trenches.
   9. Observe the construction of the subgrade and base for exterior paving.

B. Preconstruction Conference: Contractor shall conduct a preconstruction conference prior to starting work of this section, to develop a program for quality control of the work. The requirements for observation of the work by the Soils Engineer, scheduling of the work to be observed, any additional observation requirements, and planned construction procedures, will be discussed. Minutes of the conference shall be kept, and copies distributed, with an additional copy to the Soils Engineer.

C. Source Quality Control: Obtain approval by the Soils Engineer of imported fill material before material is brought to site, and same approval of excavated material for use in fills or backfills prior to placing. Imported material shall be tested for toxic substances by an independent testing laboratory approved by the University.

1.3 SUBMITTALS

A. Provide certification, signed by an authorized representative of an approved testing laboratory, that proposed imported fill material and other earthwork materials to be brought to the site, are free from toxic substances, and are in conformance with applicable state and local regulations.
1.4 PROJECT SITE CONDITIONS

A. Protection: Provide and maintain protection to retain earth banks and to protect adjoining grades and structures from caving, sliding, erosion, or other damage. Provide suitable protection against all bodily injury. Construct all bulkheads and shoring to requirements of State and Local codes and regulations. Shore vertical banks or slope banks back as required for stability and safety. Erect temporary barricades located at least 5-feet away from the top of slopes, and provide temporary berms as required to prevent slope erosion from water.

B. Digital Photographs and Videos: Required prior to starting work of this Section.

C. Utilities: Perform work adjacent to public utilities in accordance with procedures outlined by the utility company. For work adjacent to the Owner's utility lines, excavate by hand until the utility is uncovered or sufficient clearance is defined for machine work.

D. Drainage: Collect and dispose of surface and subsurface water encountered in the course of construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide approved imported material as required if the quantity of approved site and excavated material is insufficient to complete the work.

B. Earthwork Materials: Approved excavated or imported granular soil such as silty sand having an expansion index of 20 or less, and containing not more than 20 percent by weight of material passing the No. 200 sieve, free from trash, roots, organic material, clay lumps, and rocks over 6" size.

C. Gravel Fill Material: From approved source, 90 percent to 100 percent passing a 3/4" sieve, 0 percent to 10 percent passing a No. 4 sieve, and 0 percent to 3 percent passing a No. 100 sieve.

D. Sand: ASTM D2488, with not more than 3 percent passing No. 200 sieve.

PART 3 - EXECUTION

3.1 COMPACTION CONTROL

A. Unless otherwise specified hereafter, compaction densities shall be not less than the following. Moisten or aerate material to specified moisture content, then uniformly compact the fills and backfills in maximum 8" thick loose layers to 90 percent of the maximum dry density determined by ASTM D1557. This is the minimum compaction; average shall be at least 92 percent. Flooding or jetting is not allowed. In areas to be landscaped only, fills may be placed in 12" layers and compacted to 85 percent of maximum dry density.

3.2 MOISTURE CONTENT CONTROL

A. Material to be compacted shall be brought to uniform moisture content varying no more than zero percent below or 3 percent above optimum moisture content. Obtain approval by the Soils Engineer of the...
moisture content before performing further grading operations. Mix, dampen, or dry soils as required to achieve specified moisture content.

3.3 SITE CLEARING

A. Coordinate with the Demolition Contractor for the demolition and removal of the existing piles and pile caps, grade beams and asphalt paving and base course from areas to receive the new building as shown on the drawings as indicated. Asphalt paving may be pulverized and blended with site soils to be used for engineered fill material, provided the specified results of compaction and grading are obtained.

3.4 REMOVAL AND REPLACEMENT OF UNSUITABLE SOILS

A. General: As indicated in the soils report, unsuitable soils conditions may be encountered in the area of the building to depth of approximately 6'-0". If any of the following conditions occur, the provisions of this paragraph shall apply.
   1. Dissimilar native materials are encountered across the building footprint.
   2. Incompetent zones are encountered.
   3. The subgrade becomes disturbed during construction.
   4. Creation of a level pad requires a cut/fill transition within the building pad.
   5. The Soils Engineer determines that field conditions require procedures specified herein.

B. In the event that any of the above conditions occur, the following procedures shall be performed.
   1. After removal of existing paving, remove all uncontrolled fill soils, all upper loose, firm, porous or disturbed natural soils from areas to receive footings, slabs, walks and paving to a distance of 5 feet beyond edges of same.
   2. Soils shall be removed to a depth that will provide not less than 2 feet of compacted soil below building slabs and 5 feet beyond, and 18 inches below exterior paving, walks, and new asphalt paving.
   3. After excavating, the exposed soils shall be inspected to verify removal of all unsuitable deposits. Remove all rocks larger than 8" in largest dimension.
   4. The exposed soils shall be scarified to a depth of 6", moisture added as required and recompacted to not less than 90 percent of the maximum dry density at optimum moisture content in accordance with ASTM D1557. Fill shall be placed in loose lifts not exceeding 8" in thickness and compacted to 90 percent as defined above. Compaction shall be accomplished continuously over the entire area. Sufficient passes shall be made to ensure that specified density is obtained.

3.5 EXCAVATION AND BACKFILLING FOR FOUNDATIONS AND STRUCTURES:

A. Foundation Soils: Excavate for foundations to sizes indicated, clean, and leave in condition recommended by Geotechnical Investigation Report. Prior to placement of forms, reinforcing, or concrete, obtain approval of Soils Engineer and building department as required, for proper conditions and suitable bearing materials.

B. Perform excavation to the dimensions and elevations indicated on drawings, with additional space allowed as required for the installation and stripping of forms, and inspection of the various types of work, except where approval may be given to deposit certain miscellaneous concrete directly against earth banks.

C. Provide lateral support for excavations within and adjacent to structures, foundations and slabs-on-grade to prevent caving, earth movement or loosening of subgrade materials.
D. Adverse Subsurface Conditions: Notify Project Engineer should unsuitable bearing soil or other adverse subsurface conditions be found which are not indicated by the drawings or specifications.

E. Unauthorized Excavation: If excavations are carried below the elevations indicated without written authorization, provide satisfactory construction to correct the fault as approved, at no additional contract cost.

F. Backfill Beside Foundations:
1. Backfilling against concrete shall not be done until concrete has attained its 28-day compressive strength, unless specifically approved otherwise.
2. Moisten or aerate backfill material as required to attain specified moisture content. Place backfill material adjacent to structures and compact in a manner that prevents wedging action or eccentric loading upon or against the structures. Step or serrate slopes bounding or within areas to be backfilled to prevent sliding of the fill. Do not place material on surfaces that are muddy. Do not use equipment for backfilling operations or for the formation of embankments against structures that will overload the structure.

3.6 EXCAVATION AND BACKFILLING FOR UTILITIES

A. Trenching and excavating for underground piping, conduits, and related items are performed under other sections. Conform trenching operations to the following requirements:
1. Trenches: Excavate trenches to widths required for proper laying of pipe, with banks as nearly vertical as practicable. Bring bottoms of trenches to the required depths, all accurately graded to provide uniform bearing on undisturbed soil for entire length of each section of pipe, except where it is necessary to excavate for pipe bells or for pipe bedding specified in other sections.
2. Methods: Machine excavation method may be used down to rough elevations. Perform fine grading and trimming by hand method.
3. Trench Backfilling: Conform to Paragraph "Compaction" except compact all backfill to at least 95 percent of maximum dry density where the trenches are located in paved areas or under building or structures. Take precautions in placing and compaction of backfill to avoid damaging pipes, ducts, conduits, and structures. The upper 12 inches of trench backfill materials shall consist of on-site soil material, compacted as specified.

3.7 SUBGRADE PREPARATION FOR CONCRETE

A. Prepare subgrade for concrete items placed directly on earth by excavating, filling, and grading as required and as specified, and bring to optimum moisture content. Excavate the existing subgrade to a depth of 12 inches, moisture condition, and recompact to 90 percent. Finish the subgrade within 0.10-foot tolerance when tested along a 10-foot straightedge in any direction at any location. Compact to density specified for fills, and maintain moisture content until concrete is placed.

3.8 ASPHALTIC CONCRETE PAVING AREAS

A. Bring areas to required elevations and grades by clearing and preparation, cutting, filling, and grading, as shown and specified herein. Allow for thickness of subsequent materials. Excavate the existing subgrade to a depth of 12 inches, moisture condition, and recompact to 90 percent. Final fine grading and compaction is specified as a part of the paving operations. Coordinate with Section 02510 requirements.
3.9 LANDSCAPE AREAS
   A. Bring to nominal 0.10-foot below required grades except where topsoil fill occurs, and finish with smoothly curving contours at grade changes and slopes, as approved. Grade to allow for thickness of topsoil fill. Avoid excessive compaction in all areas.

3.10 GRADING
   A. After completion of construction, and immediately prior to final acceptance, all surfaces not covered by landscaping, paving, or other materials shall be raked clean and uniformly graded to elevations shown on drawings, with smoothly curving contours.

3.11 DISPOSAL
   A. Clean up and remove all trash, debris, waste, and surplus and rejected earthwork materials from the site to a legal disposal area. Conform to pertaining laws, codes, and regulations, obtain and pay for required hauling and dumping permits, and pay all dumping charges. Perform trucking and material handling in a careful manner to prevent spillage and dusting or damage to surfaces and structures. Remove planks used to protect surfaces subject to public traffic at finish of each day's operations. Maintain public streets and sidewalks in broom clean condition.

3.12 PROTECTION
   A. Protect newly graded areas from traffic, erosion, and settlement. Repair and reestablish damaged or eroded slopes, elevations, or grades and restore surface construction prior to acceptance.

3.13 FIELD QUALITY CONTROL:
   A. Refer to Division 1 for additional requirements, specifically Section 01400.
   B. Testing: Testing Laboratory will take test samples and perform materials, moisture content, compaction densities, and other tests to the extent and by the methods directed by the Soils Engineer.
   C. Professional Certificates: Upon completion, Soils Engineer will furnish written certificates that earthwork and compaction densities conform to requirements herein.
SECTION 02210 – GEOTECHNICAL DATA

PART 1 - GENERAL

1.1 INVESTIGATION

A. Soil, geologic and seismic investigations were conducted at the site, and the results are to be found in the following report:
   1. Geotechnical Investigation Proposed Art Center, California State University, Bakersfield, Dated March 26, 2008.
      a. Soils Engineer Project Number: G08-047-11B
      a. Soils Engineer Project Number: G08-048-11B

B. Report Prepared By:
   1. BSK Associates
      117 “V” Street
      Bakersfield, CA 93304
      Phone: 661-327-0674

C. A copy of this report is available for review at the office of the Geotechnical Engineer and the office of the Architect. Bidders are urged to examine all geotechnical investigation data and make their own examination of the site before bidding.

1.2 INTERPRETATION

A. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that Owner and Architect will not be responsible for interpretations or conclusions drawn therefrom by Bidder. The Owner and Architect further disclaim responsibility for interpretation of the data by bidders, as in projecting soil-bearing values, rock profiles, soil stability and the presence, level and extent of underground water. Data are made available for convenience of Bidder.

B. Soil Investigation/geotechnical evaluation is not part of the Contract Documents.

C. Additional test borings and other exploratory operations may be made by Bidder at no cost to Owner. Upon conclusion of Bidders own investigation, restore the site as directed by Owner.

END OF SECTION 02210
SECTION 02300 – EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies earthwork.

1.2 RELATED SECTIONS

A. Section 02210: Geotechnical Data.

B. Section 02621: Foundation Drainage

C. Section 02751: Concrete Pavement

D. Section 03300: Cast-in-Place Concrete.

1.3 QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

B. Testing and Inspection Service:
   1. Comply with pertinent provisions of Division 1, Section 01405.
   2. Geotechnical Engineering Services: Compaction testing and compaction observation and inspection will be required. Payment and reports shall be in conformance with Division 1, Section 01410.
      a. Determine compaction per ASTM D 1557.
      b. Comply with Title 24, Part 2, Chapter 33.

C. Geotechnical Investigation Report: Refer to Section 02210.

1.4 PROJECT CONDITIONS

A. Site Information: Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that the University will not be responsible for interpretations or conclusions drawn there from by Contractor. Data are made available for convenience of Contractor.
   1. Additional test borings and other exploratory operations may be made by Contractor at no cost to the University.

B. Noise and Dust Abatement: Exercise all reasonable and necessary means to abate dust, dirt rising and undue noise. Perform necessary sprinkling and wetting of construction site to allay dust.

C. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of protection during earthwork operations.
1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility University immediately for directions.
2. Cooperate with University and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility University.
3. Do not interrupt existing utilities serving facilities occupied and used by University or others, except when permitted in writing by Project Engineer and then only after acceptable temporary utility services have been provided.
4. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.

D. Use of Explosives: Use of explosives is not permitted.

E. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
   1. Operate warning lights as recommended by authorities having jurisdiction.
   2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

F. Existing Conditions: Prior to commencing Work at site, verify agreement of existing conditions with indicated conditions. Notify Project Engineer in writing of discrepancies found. Start of Work without notification constitutes acceptance of conditions, without cause for extra costs.
   1. Filled Excavations and Buried Structures: Investigate site during clearance and earthwork operations for filled excavations, buried structures such as cesspools, cisterns, foundations. If such conditions are found, immediately notify Project Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill Material: Provide clean, well pulverized, non-expansive soil free from rocks greater than 6 inches in diameter, vegetation, trash or other debris, and subject to approval of Geotechnical Engineer.
   1. Soils imported to the site for use as fill for subgrade materials shall be predominantly granular and non expansive (Expansive Index less than 20) and contain sufficient fines (approximately 20 percent) so as to be relatively impermeable when compacted.
   2. Import material, if required, to be approved at borrow site by Geotechnical Engineer prior to importation. Notify the Geotechnical Engineer of import locations a minimum of 72 hours prior to its proposed use.
   3. Existing on-site earth material is suitable as fill provided it is free from rocks greater than 6 inches in diameter, organic matter and other deleterious materials.

B. Crushed Rock Base: Crushed rock conforming to following gradation:
   1. Sieve Size: Percentage Passing:
      3/4 inch  90-100
      #4       0-10
      #10      0-3
PART 3 - EXECUTION

3.1 SITE CLEARING

A. General: Clear area within building pad of surface vegetation, improvements, or obstructions including, but not limited to, trash, debris, asphaltic pavement, and pieces of broken concrete from demolition of existing structures and their foundations, that interfere with installation of new construction and remove from site.
   1. Remove such items elsewhere on the site or premises as specifically indicated. Removal includes new and old stumps of trees and their roots. Carefully and cleanly cut roots and branches of trees indicated to be left standing, where such roots and branches obstruct new construction.

B. Clearing and Grubbing:
   1. Clear the project site of trees, shrub, grass, weeds, and other vegetation, except for those indicated to be left standing.
   2. Completely remove stumps, roots, and other debris protruding through the ground surface. Use only hand methods for grubbing inside the drip line of trees indicated to be left standing.
   3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
   4. Place fill material in horizontal layers not exceeding 6 inches loose depth, and thoroughly compact to a density equal to adjacent original ground.

3.2 SUBGRADE PREPARATION

A. Art Center and Satellite Cooling Plant:
   1. Overexcavate the subgrade soils within the building pad areas to provide a uniform compacted fill blanket per soils report or at a minimum of 3 feet below the slab subgrade or a minimum of 3 feet below footing bases, or 5 feet below existing grade, whichever is greater.
      a. If physically possible, lateral extent of overexcavation beyond building pad limits should be 5 feet.
      b. Compact fill material to minimum of 95 percent of relative compaction per ASTM D 1557.
   2. In addition, remove undocumented fill in building areas, and replace with properly compacted fill with a minimum 95 percent relative compaction per ASTM D 1557.
      a. Depth of undocumented fill was observed to be approximately 5 feet below existing grade at boring B-3 location.
      b. If undocumented fills are observed to extend deeper at other locations, remove and replace with properly compacted fill.
      c. Exposed subgrade to be observed by Geotechnical Engineer to verify removal of unsuitable materials.

B. Thermal Energy Storage Tank (TES):
   1. Overexcavate the subgrade soils within the TES Tank area to provide a uniform compacted fill blanket per soils report or at a minimum of 3 feet below bottom of concrete ring wall.
      a. Horizontal extent of overexcavation beyond outer edge of ring wall footing limits should be 5 feet.
      b. Compact fill material to minimum of 95 percent of relative compaction per ASTM D 1557.
   2. In addition, remove undocumented fill in TES Tank areas, and replace with properly compacted fill with a minimum 95 percent relative compaction per ASTM D 1557.
      a. Depth of undocumented fill was observed to be approximately 5 feet below existing grade at boring B-4 location.
      b. If undocumented fills are observed to extend deeper at other locations, remove and replace with properly compacted fill.
c. Exposed subgrade to be observed by Geotechnical Engineer to verify removal of unsuitable materials.

3. Compact structural backfill and 6 inches of imported crushed aggregate base immediately below tank base to minimum of 95 percent relative compaction per ASTM D 1557.

C. Walkways, Driveways, and Other Pavement Areas:
1. Overexcavate subsoils beneath walkways, driveways, and other pavement areas to facilitate construction of 2 foot thick compacted fill blanket.
2. Lateral extent of overexcavation should be equal to fill depth.

D. Scarifying: Prior to placing fill, scarify the exposed surface soils to a minimum depth of 8 to 10 inches, moisture-conditioned (wetted or dried) to at least optimum moisture content and compacted to a minimum of 90 percent relative compaction based on ASTM D 1557.

E. Compaction:
1. Cohesive Soils: Place cohesive soils in loose lifts not exceeding 6 inches, moisture-condition to approximately 2 to 4 percentage points above optimum moisture content, and compact to minimum 90 percent relative compaction.
2. Granular Fill Materials: Place in loose lifts of 6 to 8 inches, moisture-condition to near-optimum, and compact to minimum 90 percent relative compaction.

3.3 EXCAVATION, GENERAL

A. Excavation consists of removal and disposal of material encountered when establishing required grade elevations.

B. Stability of Excavations: Maintain sides and slopes of excavations in a safe condition until completion of backfilling. Provide not less than minimum requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.

C. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage. Locate and retain soil materials away from edge of excavations.

D. Temporary construction excavations may be required for construction of pile caps, footings for minor structures and utility trenches.

E. Temporary construction excavations may be made vertically without shoring to a depth of 4 feet below adjacent surrounding grade. For deeper cuts, the slopes shall be properly shored or sloped back at least 1H:1V (Horizontal:Vertical) or flatter. The exposed slope face shall be kept moist (but not saturated) during construction to reduce local sloughing. No surcharge loads shall be permitted within a horizontal distance equal to the height of cut from the toe of the excavation unless the cut is properly shored. Excavations that extend below an imaginary plane inclined at 45 degrees below the edge of any nearby adjacent existing site facilities or existing foundations shall be properly shored to maintain foundation support of the adjacent facilities and structure.

F. All excavations and shoring systems shall meet, as a minimum, the requirements of the State of California Occupational Safety and Health Standards. Stability of temporary slopes is the responsibility of the Contractor.
ART CENTER AND SATELLITE COOLING PLANT
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD
BAKERSFIELD, CA

3.4 EXCAVATION FOR STRUCTURES

A. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction required, and for inspection.

B. In excavating for footings and foundations, take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete is placed. Trim bottoms to required lines and grades to leave solid base to receive concrete.

3.5 EXCAVATION FOR PAVEMENTS

A. Cut surface under pavements to comply with cross-sections, elevations and grades as shown.

3.6 EXCAVATION FOR TRENCHES

A. Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room. Provide 6 to 9 inches clearance on both sides of pipe or conduit.

B. Excavate trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations.

C. Where rock is encountered, carry excavation 6 inches below required elevation and backfill with a 6 inch layer of crushed stone or gravel prior to installation of pipe.

D. Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for entire body of pipe.

E. Do not backfill trenches until tests and inspections have been made and backfilling authorized by the Project Engineer. Use care in backfilling to avoid damage or displacement of pipe systems.

3.7 DEWATERING

A. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

B. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

C. Convey water removed from excavations and rain water to collecting or run-off areas. Provide and maintain temporary drainage ditches and other diversions outside excavation limits for each structure. Do not use trench excavations as temporary drainage ditches.

3.8 GRADING

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.
B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.
   1. Where grades are not indicated, grade uniformly level or slope between points for which elevations are given. In absence of more specific grading information, ground shall slope away from buildings for a minimum distance of 20 feet, at a minimum slope of 2 per cent. Grade trenches and other drainage flow lines to slope uniformly to avoid standing water.

C. Finish surfaces free from irregular surface changes, and as follows:
   1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10 foot above or below required subgrade elevations.
   2. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 0.10 foot above or below required subgrade elevation.
   3. Pavements: Shape surface of areas under pavement to line, grade and cross-section, with finish surface not more than 1/2 inch above or below required subgrade elevation.

D. Grading Surface of Fill Under Building Slabs:
   1. Grade smooth and even, free of voids, compacted as specified, and to required elevation.
   2. Provide final grades within a tolerance of 1/2 inch when tested with a 10 foot straightedge.

E. Expansion index tests shall be performed on the subgrade soils subsequent to grading to verify the expansion potential of the slab subgrade soils. For “low” expansion potential soils observed at the boring locations, the top 12 inches below the slab subgrade shall be maintained in a thoroughly moist condition of approximately 2 to 4 percentage points above optimum moisture content. The slab subgrade shall be tested immediately prior to placement of the gravel base.

3.9 BACKFILL

A. Backfill excavations as promptly as work permits, but not until completion of the following:
   1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
   2. Inspection, testing, approval, and recording locations of underground utilities.
   4. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.
   5. Removal of trash and debris.
   6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

B. Placement and Compaction:
   1. Place backfill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
      a. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to 90 percent of maximum dry density.
      b. Place backfill materials evenly adjacent to structures, piping or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping or conduit to approximately same elevation in each lift.
      c. Do not compact backfill by jetting, flooding or puddling methods.
3.10 BUILDING SLAB BASE COURSE

A. General: Building slab base course consists of placement of crushed rock material, in layers of indicated thickness, over subgrade surface to support concrete building slabs.

B. Placing: Place crushed rock material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting material during placement operations.

C. When a compacted crushed rock base course is shown to be 6 inches thick or less, place material in a single layer. When shown to be more than 6 inches thick, place material in equal layers, except no single layer more than 6 inches or less than 3 inches in thickness when compacted.

3.11 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction: Allow testing service to inspect and approve subgrades and fill layers before further construction work is performed.
   1. Perform field density tests in accordance with ASTM D 1556 (sand cone method) or ASTM D 2167 (rubber balloon method), or ASTM D 2922 (Nuclear Method) as applicable.

B. If in opinion of Project Engineer, based on testing service reports and inspection, subgrade or fills which have been placed are below specified density, provide additional compaction and testing at no additional expense to University.

C. Cracking or settlement of paving or other finish materials over utility trench locations shall be conclusive proof of trench failure. Remove and recompact trench backfill material and replace damaged paving or other finish material as required at no additional cost to the University.

3.12 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

3.13 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from University's Property:
   1. Remove waste materials, including excess and unacceptable excavated material, trash and debris, and dispose of it off University's property in a legal dump site.
3.14 LANDSCAPE TOPSOIL

A. Top 12 inches of soil shall be landscape quality topsoil, clean and granular, free of rocks, weeds, vegetation, trash and debris. Place 2 inches of excess soil to allow for settlement.

END OF SECTION 02300
SECTION 02510 – ASPHALT CONCRETE PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 1 applies to this Section. Provide asphalt concrete paving, complete.

B. This section specifies subgrade preparation, soil sterilization, aggregate base course, tack coat, asphaltic concrete paving, asphalt emulsion seal coat, redwood headers, patching and repair of existing pavement.

1.2 QUALITY ASSURANCE

A. Proportioning of Plant Mix: Determine the exact proportions of bituminous binder and mineral aggregate required to produce a mixture equal to mix quality specified.

1.3 SUBMITTALS

A. Product Data: Submit technical product data and application directions for all manufactured products.

B. Certificates and Statement: Submit certificates from all asphalt concrete products suppliers attesting that quality, gradation, proportions, and mixing of materials supplied conform to requirements specified. Materials not conforming to specified requirements are defective. Reject defective materials whether or not in place. Submit a certified statement supported by weight tickets showing the following information:
   1. Calculations showing minimum amount of asphaltic concrete materials required for total area to be paved.
   2. Amounts actually installed.

1.4 JOB CONDITIONS

A. Provide protection and repair adjacent surfaces and areas that may be stained or damaged as a result of installation. Protect installed paving until final acceptance. Repair or replace damaged or defective paving to original specified condition.

1.5 WARRANTY

A. In addition to warranty required in Division Section 01740, provide 2 year warranty against weed or plant growth through paving for two years. Warranties shall cover all portions of asphaltic concrete in which creeping, shoving, cracking, raveling, or softening occurs or in which any weed growth occurs, and depressed areas which collect water due to improper grading, placing, or defective materials during the warranty period. Repairs include the restoration of adjoining or applied materials and finish items.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Soil Sterilizer: An approved standard product non-selective borate-chlorate type sterilizer having minimum 46% boron-trioxide equivalent. Tebuthiuron, marketed as "Spike 80W", manufactured by Elanco Products Company, Indianapolis, IN 46285, may be used as an alternate to boron trioxide products. In either case, the material shall be approved for use under asphalt paving by the State of California EPA.

B. Aggregate Base Course: State Standard Spec Section 26, Class 2, 3/4" size gradation maximum.


D. Asphaltic Concrete Surface Course: 3/4" mix, asphalt type AR-4000 or AR-8000, aggregate graded as follows:

<table>
<thead>
<tr>
<th>SIEVE SIZE, SQUARE OPENINGS</th>
<th>PERCENT PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>100</td>
</tr>
<tr>
<td>3/4”</td>
<td>90 – 100</td>
</tr>
<tr>
<td>3/8”</td>
<td>64 – 80</td>
</tr>
<tr>
<td>No. 4</td>
<td>46 – 60</td>
</tr>
<tr>
<td>No. 8</td>
<td>35 – 45</td>
</tr>
<tr>
<td>No. 30</td>
<td>17 – 29</td>
</tr>
<tr>
<td>No. 200</td>
<td>2 – 7</td>
</tr>
<tr>
<td>Asphalt binder</td>
<td>4.5 – 5.8</td>
</tr>
</tbody>
</table>

E. Asphalt Emulsion Seal Coat: "Guardtop", manufactured by Industrial Asphalt, 13130 East Los Angeles Street, P.O. Box 2263, Irwindale, CA 91706 (818) 814-1428, "Slurry-Mix" by Ted R. Jenkins Co., Inc., or "Plush Tex" by Koch Asphalt Company.

1. The material shall conform to the following:
PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>Physical Property, Units</th>
<th>Test Method</th>
<th>Acceptable Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cone penetration at 77° F, dmm</td>
<td>ASTM D 217</td>
<td>340 min., 430 max.</td>
</tr>
<tr>
<td>Nonvolatile components, percent</td>
<td>325°, 1.5 hours</td>
<td>60 min., 70 max.</td>
</tr>
<tr>
<td>Percent by weight nonvolatile soluble in trichloroethylene</td>
<td>ASSHTO T 45</td>
<td>20 min., 35 max.</td>
</tr>
<tr>
<td>Wet track abrasion test</td>
<td>ASTM 3910</td>
<td>30 Average</td>
</tr>
<tr>
<td>Accelerated weathering</td>
<td>Fed Spec TT C-555B</td>
<td>Passes</td>
</tr>
<tr>
<td>Resistance to wind driven rain at 98 mph</td>
<td>Fed Spec TT C-555B</td>
<td>Passes</td>
</tr>
<tr>
<td>Ultraviolet resistance, 12 years</td>
<td></td>
<td>No cracking, peeling, chipping, flaking</td>
</tr>
<tr>
<td>Density, pounds per gallon</td>
<td></td>
<td>10.9</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>Black</td>
</tr>
</tbody>
</table>

2. Provide crack fillers and related materials of same manufacturer.

F. Redwood Headers: as graded by Redwood Inspection Service. Redwood headers and stakes shall be 2" x 6" construction heart rough redwood as graded by Redwood Inspection Service. Headers on curves shall be laminated 1 " x 6" Stakes shall be 2- by 6- by 18-inch long. Splice headers with 2- by 4- redwood, minimum 36-inches long. Use 12 d 16d common galvanized nails for assembling headers.

PART 3 - EXECUTION

3.1 PREPARATORY WORK

A. Subgrade Preparation: Conform to Green Book Subsection 301-1. Proof roll the subgrade and perform all necessary rolling and compacting to obtain firm, event subgrade surface. Fill and consolidate depressed areas. Remove unsuitable materials, and replace with clean fill. Compact top 6" to minimum 95% relative compaction, determined as specified in Section 02200, at any location. Maintain the subgrade slightly above optimum moisture content until covered with subsequent materials.

B. Manhole and Catch Basin Frame Adjustments:
1. Verify frames for manholes, catch basins and other such units, within areas to be paved, are at their proper elevation.
2. Adjust frames as required to match paving. Provide temporary closures over openings until completion of rolling operations. Remove closures at completion of the work. Set covers to grade, flush with the surface of adjoining pavement surface.

C. Soil Sterilizing: Apply sterilizer according to manufacturer's directions using dry or aqueous spray process, minimum quantity of dry undiluted material per 100 SF of paving conforming to the manufacturer's directions for control of medium and heavier weed growth and to meet warranty requirements. If necessary, apply supplemental watering to fully dissolve all sterilizer and obtain 2" to 3" penetration into the subgrade. Reroll treated subgrade to specified compaction. Do not apply sterilizer during rain or windy weather and prevent contamination of landscaping areas.
3.2 asphalt concrete paving

A. Aggregate base course: Conform to Green Book Subsection 301-2, place in one or two layers as required to obtain 95% relative compaction. Deliver to site as a uniform mixture. Construct to indicated compacted thickness.

B. Asphalt concrete: Conform to Green Book Subsection 302-5 including the requirements for smoothness and density. Construct paving to minimum compacted thickness indicated.
   1. Where thickness of more than 2-inches is shown, install asphalt surface materials in two courses, leveling course and surface course, total compacted depth as scheduled.
   2. Place the asphalt concrete mixture on the prepared surface, spread and strike-off. Spread mixture at minimum temperature of 225 degrees F. Inaccessible and small areas may be placed by hand. Place each course to the required grade, cross section and scheduled compacted thickness.
   3. Place materials in strips not less than 10'-6" wide, unless otherwise directed. After the first strip has been placed and rolled, place all succeeding strips and extend rolling to overlap previous strips. Complete base course for a section before placing surface course materials.
   4. Carefully make joints between old and new pavements, and between successive day's work, to ensure a continuous bond between adjoining work. Construct joints to have the same texture, density and smoothness as other sections of the asphalt concrete course.
   5. Apply tack coat to contact surfaces of existing pavement, curbs and structures abutting pavement.
   6. Begin rolling operations when the mixture will bear the weight of the roller without excessive displacement. Compact areas inaccessible to rollers with hot hand tampers or vibrating plate compactors.
   7. Perform breakdown rolling immediately following the rolling of transverse and longitudinal joints and the outside edge. Check grade and smoothness after the breakdown rolling. Repair displaced areas by loosening and filling with hot loose material before continuing rolling.
   8. Perform second rolling as soon as possible after the breakdown rolling, while the mixture is hot and in condition for proper compaction. Continue the second rolling until the mixture has been thoroughly compacted.
   9. Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until all roller marks are eliminated and the course has attained maximum density. Provide a smooth unyielding surface, true to thickness and elevation required.
   10. Remove and replace mixtures that become mixed with foreign materials and all defective areas. Cut out such areas and fill with fresh, hot asphalt concrete. Compact by rolling to the required surface density and smoothness.
   11. Remove deficient areas for the full depth of the course. Cut sides perpendicular and parallel to the direction of traffic with edges vertical. Apply a tack coat before placing asphalt concrete mixture.
   12. After final rolling, do not permit vehicular traffic on the pavement until it has cooled and hardened and in no case sooner than 12 hours.

C. Headers: Provide continuous redwood headers where shown, and at all edges of paving which are not adjacent to vertical concrete surfaces. Headers shall be placed with the tops flush with asphaltic concrete surface at all edges of pavement except where it abuts against rigid structures, curbs, or gutters. Stakes shall be spaced not over 3 feet apart and shall be driven into the ground so that tops are 1/2 inch below the tops of headers.

D. Seal coat: Clean and treat with weed killer all cracks 1/8" and larger, then fill with crack filler. Remove all oil and grease deposits, loose dirt, and raveled particles. Immediately prior to application of seal coat, spray with mist of water to damp surface free from puddles.
   1. For existing or weathered surfaces, prime surface using specified tack coat emulsion, diluted one part to 5 parts water, as recommended by seal coat manufacturer. Apply at rate of one gallon per 100 square feet. Allow to dry.
2. Apply seal coat in 2 applications. The first coat shall be spread and allowed to dry. Then apply second coat. The application rate for the 2 coats shall be between 20 and 45 gallons per 1,000 square feet, depending on porosity of the surface.

3. Omit screenings unless specifically directed otherwise.

3.3 PATCHING EXISTING PAVEMENT

A. Where new paving joins existing, and where trenches are cut in existing paving, patch with asphalt concrete. Prior to patching, sawcut edges at least 6” back from all ragged edges and compact subgrade to a firm, unyielding subgrade.

B. Field verify extent and location of paving scheduled for replacement, repair, and resurfacing. The work includes filling trenches in existing paving, where indicated or required because of utility construction.

C. Coordinate junction of new and existing pavement. Saw cut existing pavement to provide a uniform straight-line transition. Meet existing surface levels and maintain drainage slopes. Feathering of transitions is not acceptable.

D. Crushed rock base of existing pavement may be reused, following approval by Soils Engineer, provided its integrity is maintained. Provide new base material as specified, if existing in insufficient or unsuitable. Compact crushed rock base of same thickness as existing to 1” below existing asphalt concrete pavement.

E. Apply emulsion or hot liquid asphalt tack coat to sawcut edges prior to patching, Apply and compact asphalt concrete pavement making neat edges where new and existing join.

3.4 PROTECTION AND CLEANING

A. Protect newly placed material from traffic by barricades or other suitable methods acceptable to the Project Engineer. Protect asphalt paving from construction and vehicular damage until project acceptance.

B. Sweep asphalt paving and wash free of stains, discolorations, dirt and other foreign material immediately before project acceptance. If stains remain after cleaning, apply a coat of sealer.

3.5 FIELD QUALITY CONTROL

A. Provide field quality control testing and inspection during asphaltic concrete paving operations. Cooperate with, provide access to the work, obtain samples and assist testing agency and their representatives in execution of their functions.

B. Before constructing base course, field verify subgrade surfaces are adequate and meet or exceed design-bearing values. Provide a minimum of one test for each type of paving required.

C. When requested, perform laboratory tests on asphalt pavement mixes to determine conformity with specified requirements.

D. Test in-place asphalt base course and surface courses for compliance with density, thickness and surface smoothness. Take not less than 4” diameter pavement specimens of each completed course. Repair test specimen holes to match adjacent work.
1. Average density of in-place material: Equal to or greater than 97%, with no individual determination less than 95% of average density of laboratory specimens.

2. Perform one test for density for each course for each day's work.

3. Thickness: Make one test for each 5,000 square feet of each type of paving. In-place compacted thickness tested in accordance with ASTM D 3549 will not be acceptable if exceeding following allowable variations:
   a. Base Course: Plus or minus 1/2 inch.
   b. Surface Course: Plus or minus 1/4 inch.

E. Surface Smoothness: Test finished surface of each hot-mixed asphalt course for smoothness, using 10-foot straightedge applied parallel with and at right angles to centerline of paved area. Surfaces will not be acceptable if exceeding the following tolerances for smoothness:
   1. Base Course Surface: 1/4 inch.
   2. Wearing Course Surface: 3/16 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

F. Drainage Test: Flood all paving with water when rolling is completed and paving is cool. Remove paving in improperly draining areas and install properly draining paving as directed, at no extra cost to University. Correction of low areas by skin patching is not acceptable.

END OF SECTION 02510
SECTION 02520 – SITE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 1 applies to this Section. Provide exterior concrete work, including curbs, ramps, gutters, driveway aprons, swales, walks and pavement, as indicated, specified, and required.

1.2 SUBMITTALS

A. Layout Drawings: Provide a layout drawing showing locations of each type of pavement and construction, and dimensioned locations of all expansion and control joints.

B. Product Data: Submit for expansion and control joint material.

C. Site Samples:
   1. Prepare following samples at the site, cast in the directed locations and orientations. Prepare as many samples of each type of concrete as are required for approval. Remove samples from the site when no longer needed and removal is approved. Approved samples may be part of permanent construction if meeting all other requirements shown and specified and are so approved.
   2. Slab Samples: Prepare minimum 4-foot square samples of each required slab finish. Include a transverse expansion joint, scoring, and edging. Where paving adjoins other materials such as pavers, include one edge of sample constructed of the other materials.

1.3 QUALITY ASSURANCE

A. Conform to Division 1 and 3 for requirements not specified in detail herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete:
   1. Portland cement: ASTM C150, Type I or Type II.
   2. Aggregates: ASTM C33, from approved source to insure uniform quality and grading. Deliver so that moisture content variations will not decrease production of reasonably uniform concrete. Do not use aggregates that are reactive with alkalis.
   3. Water: Clean, fresh and potable.

B. Strength: Minimum ultimate compressive strength of 3,000 psi. Refer to Division 1 for testing requirements.

C. Reinforcing:
   1. Bars: ASTM A615, grade 60.
   2. Wire: ASTM A82.

D. Expansion and Control Joints:
1. Expansion joints for slabs: Conform to Green Book. Subsection 201-3.
2. Expansion joints for curbs and gutters: Asphalt impregnated fiber filler material, 1/2 inch thick.

E. Curing Compound: Conform to Green Book Subsection 201-4.

F. Polyethylene Film: Clear, 10 mil thick, "Visqueen", or equal. Provide compatible tape for sealing joints.

PART 3 - EXECUTION

3.1 ON-SITE CONCRETE WORK

A. Construct all site concrete of 2,500 psi concrete unless otherwise indicated or specified. Provide reinforcing bars or mesh where indicated. Form accurately to profiles shown, using wood, metal or plastic forms as approved. Place and handle concrete in manner that will avoid segregation of ingredients.

B. Refer to Section 03300 for additional requirements.

3.2 SUBGRADE PREPARATION:

A. Refer to Section 02200 for additional requirements.

B. General: Conform to Green Book Subsections 301-1.2 through 301 - 1.4, inclusive, performed under the supervision of the Soils Engineer.

C. Maintenance of subgrade: The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the concrete is placed.

3.3 CONCRETE SLABS, PADS, WALKS, DRIVEWAY APRONS, CURBS, GUTTERS AND OTHER EXTERIOR CONCRETE FLATWORK

A. Form Setting: Conform to Green Book Subsection 303-5.2.1. Concrete surfaces, where left exposed, shall be formed on all sides with plywood with taped joints to give a smooth, uniform straight finish.

B. Reinforcing steel shall be securely tied in place. Do not use bars with kinks or bends not shown on drawings. Reinforcing steel shall be clean, free from rust, oil, scale, or any foreign material. Place all reinforcing as detailed and comply with typical detail for bends, splices, clearance, etc., and with requirements of the Uniform Building Code.

C. Placing Concrete: Conform to Green Book Subsection 303-5.3 and Section 03300.

D. Expansion Joints:
1. Concrete Curbs: Provide 1/2" thick expansion joints at beginning and at end of curves, intersections, and 20-foot intervals between, set plumb, square, and to same profile as the curbs. Edge curb tops to 1/2" radius and vertical joints to 1/4" radius.
2. Concrete Gutters: Provide 1/2" thick expansion joints as above for curbs.
3. Concrete Walks: Provide 1/2" expansion joints as specified for curbs and where walks abut rigid structures, aligned with joints in curbs where adjoining. Provide expansion joints at 20-foot intervals in concrete walks.

E. Control Joints shall be formed joints. Tops of joints shall be installed flush with the concrete surface. Depth of joint shall be a minimum of 1/4 the thickness of slab. Use control joints on all curbs, curbs and gutters, and cross gutters at maximum intervals of 20 feet on center. Sawed joints may be used in lieu of the above, providing they are at least one inch deep.

F. Concrete Ramps: Construct pedestrian and disabled ramps of profile indicated. Excavate below bottoms of ramps to allow for full thickness of concrete throughout. Do not feather the concrete unless specifically indicated. Reinforce with No. 4 bars or mesh. Provide smooth transitions between ramps and adjoining surfaces. Provide uniform slopes throughout. Provide grooved pavement as detailed.

3.4 FINISHES

A. Walks and Pavement: medium broom finish perpendicular to longitudinal direction of the walk. Score walks in direction and pattern indicated or directed.
B. Gutters: Light broom finish with 3-inch wide steel trowel finish at flowlines.
C. Curbs: Steel trowel finish, followed by fine hairbrush finish.
D. Ramps: Heavy broom finish where slope is 6 percent or greater; medium broom finish where slope is less than 6 percent.
E. Paving: Medium broom finish, unless otherwise directed.
F. Driveway Aprons: Medium broom finish, unless otherwise directed.
G. See Landscape Drawings for any additional architectural finishes.

3.5 CURING

A. Concrete work shall be properly cured and protected against injury and defacement of any nature during construction operations. If weather is hot or surface has dried out, spray surface with fine mist of water, starting not later than 2 hours after final troweling. Surface of finish shall be kept continuously wet for at least 10 days. Wetting is considered emergency work and shall be performed on weekends and holidays if necessary.
B. In lieu of water curing, within 24 hours after finishing, the concrete that is not to receive special finishes, may be cured with an approved clear liquid curing compound, and applied in accordance with the manufacturer's recommendations.

3.6 BACKFILLING

A. After curing, debris shall be removed and the area adjoining the work shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.
3.7 PROTECTION

A. Completed work shall be protected from damage until accepted. The Contractor shall remove damaged concrete and clean concrete discolored during construction. Work that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints at no expense to the University. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.8 REMOVAL OF FORMS

A. Do not remove forms until the concrete has attained adequate strength to prevent damage. Take extreme care in stripping to avoid breaking off corners, marking concrete or defacing the finish surface in any way. Minimum stripping time at walls shall be 3 days.

3.9 CLEANING AND PATCHING

A. After stripping forms, clean all exposed concrete surfaces and all adjoining work stained by leakage of concrete. Remove all fins, burrs, and projections by grinding. Patch all voids, rock pockets, holes, cracks, etc., by chipping loose concrete and exposing clean sound aggregate. After inspection, dampen prepared recesses for 2 hours minimum and fill with drypack to within 1/4" of surface. Keep drypack damp for 2 days minimum. Apply mortar to final surface and keep patch damp for 5 days minimum. Entire surface of concrete to be sacked with neat cement and water after surface is cleaned and patched.

3.10 FLOOD TEST

A. All concrete gutters and concrete pavement shall be given a flood test. All concrete work where water ponds and does not run off in a reasonable amount of time, shall be removed to the nearest score or joint line and replaced to provide proper drainage.

3.11 DEFECTIVE CONCRETE

A. If concrete tests indicate that the strengths do not meet those specified, or if concrete has excessive pockets, or if reinforcing steel is exposed, or if concrete does not comply with the drawings and specifications, the defective concrete shall be removed and replaced as directed.

B. Concrete paving that shows evidence of cracking prior to completion of the project or during the 60-day maintenance period shall be replaced at no cost to the University. Such replacement shall include the entire panel of concrete in which the cracking occurs, to the nearest expansion or control joints, as approved.

3.12 OFFSITE CONCRETE WORK

A. Replace existing items are damaged by Contractor's operations. Secure and pay for required permits, inspections, engineering, and surveying. Offsite concrete work shall comply with rules and regulations of local authorities.

END OF SECTION 02520
SECTION 02621 – FOUNDATION DRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies foundation drainage system work is shown on Drawings. Foundation drainage work includes footing drainage system.

1.2 SUBMITTALS

A. Certification: Submit Certification signed by Contractor and foundation drainage system installer that installed materials conform to specified requirements and system was successfully checked and tested prior to covering with filtering and drainage fill.

PART 2 - PRODUCTS

2.1 DRAINAGE PIPE AND FITTINGS

A. Furnish drainage pipe complete with bends, reducers, adapters, couplings, collars, and joint materials.

B. Polyvinyl Chloride Pipe: ASTM D 2729.

C. Perforated Polyvinyl Chloride Pipe: ASTM D 2729.

2.2 DRAINAGE MAT

A. General: Provide prefabricate in-plane wall drainage matting as part of overall foundation drainage system. Coordinate with drainage board provided under Section 07130.

B. Drainage Mat: AKZO Industrial Systems, Enkadrain, Type 9120, 0.8 inches thick.

2.3 SOIL MATERIALS

A. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense composite.

B. Drainage Fill: Evenly graded mixture of natural or crushed gravel or crushed stone, and natural sand with 100 percent passing a 1/2 inch sieve and 0 to 5 percent passing a No. 50 sieve.

C. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone, and natural sand, with 100 percent passing a 1-1/2 inch sieve and 0 to 5 percent passing a No. 50 sieve.

PART 3 - EXECUTION
3.1 INSTALLATION

A. Protect in-place membrane waterproofing during installation of foundation drainage systems.

B. Impervious Fill at Footings: After concrete footings have been cured and forms removed, place impervious fill material on subgrade adjacent to bottom of footing. Place and compact impervious fill to dimensions indicated or, if not indicated, not less than 6 inches deep and 12 inches wide.

C. Place supporting layer of filtering material over compacted subgrade where drainage pipe is to be laid to depth indicated or, if not indicated, to a compacted depth of not less than 4 inches.
   1. After testing drain lines, place additional filtering material to a 4 inch depth around sides and top of drains.

D. Laying Drain Pipe: Lay drain pipe solidly bedded in drainage fill material. Provide full bearing for each pipe section throughout its length, to true grades and alignment, and continuous slope in direction of flow.
   1. Lay perforated pipe with perforations down and joints tightly closed in accordance with pipe manufacturers recommendations. Provide collars and couplings as required.
   2. Provide recesses in excavation bottom to receive bells for drain pipe having bell and spigot ends. Lay pipe with bells facing up slope with spigot end entered fully into adjacent bell. Seal joint in accordance with local practices having jurisdiction.

E. Testing Drain Lines: Test or check lines before backfilling to assure free flow. Remove obstructions, replace damaged components, and retest system until satisfactory.

F. Drainage Mat: Coordinate placement of drainage mat with membrane waterproofing and other foundation drainage materials.
   1. Comply with manufacturer's instructions for securing matting to substrate. Use adhesives and mechanical fasteners as recommended by matting manufacturer. Lap all edges of fabric and extend fabric around foundation drainage pipe in accordance with mat manufacturer's recommendations. Protect in-place matting during backfill operations in accordance with matting manufacturer's instructions.

G. Drainage Fill: Place drainage fill over drain lines after satisfactory testing. Completely cover drain lines to a width of at least 6" on each side and above top of pipe to finish grade (bottom of floor slab). Place fill material in layers not exceeding 6 inches in loose depth and compact each layer placed.

H. Fill to Grade: Apply impervious fill material over compacted drainage fill at footing drains, placing material in layers not exceeding 6 inches in loose depth and thoroughly compacting each layer. Carry impervious fill to indicated finish elevations and slope away from building perimeter.

END OF SECTION 02621
SECTION 02660 – WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 1 applies to this Section. Provide water distribution system as indicated, specified, and required.

B. This section specifies water piping, valves and valve boxes, hydrants with valves, lateral services extended to 5-feet from building, connections of laterals to existing mains or municipal water system, connection of building water system to laterals 5-feet from building, trenching, backfilling and compaction for water distribution system, testing and sterilization.

1.2 SUBMITTALS

A. Material List: Submit list of materials proposed for use accompanied by manufacturer's latest printed literature with technical data.

B. Certificates: Manufacturers' certification that materials meet specified requirements.

C. Provide piping plan and profile and routing shop drawings.

1.3 RECORD DRAWINGS

A. Provide complete record drawings showing dimensioned locations and depths of all piping, and exact locations of all accessories.

1.4 INSPECTION AND TESTING

A. Refer to Division 1 for procedures.

B. Inspection: Soils Engineer will inspect and test the backfilling work of this section. Notify Soils Engineer prior to commencement of work.

C. Testing: Soils Engineer will make tests to determine degree of compaction in accordance with the following ASTM test methods:

D. Report: Soils Engineer will submit a written report that trenches were backfilled with acceptable material, and that compaction meets the requirements of these specifications.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe:
   1. Cast iron and ductile iron pipes, conforming to the "Standard Specifications" Section 207-9, or thick wall Ringtite Class 150 polyvinyl chloride, meeting the requirements of AWWA C900 "Polyvinyl Chloride (PVC) Pressure Pipe".
   2. Plastic Pipe and Fittings: Ringtite Class 150 polyvinyl chloride, meeting the requirements of AWWA C900 "Polyvinyl Chloride (PVC) Pressure Pipe", extruded of an improved polyvinylchloride virgin pipe compound. Pipe and fittings shall conform to AWWA C900 Schedule 80.
      a. Solvent cement or rubber-gasket joints for pipe and fittings shall be in accordance with the manufacturer's instructions.
      b. Fittings shall be PVC Schedule 80, injection-molded of an improved PVC compound. Fittings shall conform to ASTM D 1784, Cell Classification 12454-B. Threaded nipples shall be standard weight Schedule 80 with molded threads.

B. Gate Valves: Conform to AWWA C500, iron body, bronze trim, double disc, non-rising stem, with parallel or inclined seat. Valve stems and stem nuts shall be bronze. Wedging mechanism shall be solid bronze, designed to allow the gates to function properly when water pressure is exerted from either or both directions. Valves shall open to counter clockwise rotation of the valve stem. Stuffing boxes shall have O-ring stem seals and shall be bolted and constructed so as to permit easy removal of parts for repair. Valves shall have push-on joint ends and gaskets conforming to AWWA C500. Valves shall be of one make.
   1. Valves shall be suitable for a working pressure of 200 psi. The working pressure and the name of the manufacturer cast in plain letters on the body of the valve.
   2. Equip with flanged ends, 125 lb., ASA drilled, for cast iron and ductile iron pipe. For PVC pipe, valves shall have push-on ends and gaskets.

C. Check valves: Swing type spring loaded, 200 psig working pressure, seat readily and tightly with the face of the closure elements made of a non-corrodible material such as bronze composition conforming to ASTM B62.

D. Valve boxes: Cast iron, slip adjustment type of appropriate size for valve, Alhambra No. A-3009 or equal. Valve box covers shall have round head, not less than 5-1/4" diameter, with word "WATER" cast in the top using sharp-faced letters of 1 " minimum height. Boxes shall be given a heavy coat of bituminous paint.

E. Fire hydrants: Conforming to AWWA Specifications C503, wet barrel design, equipped with a 6" flange inlet connection, two 2-1/2" outlet and a 4" suction outlet with National Standard thread. Provide 6" diameter bury, with joint to match pipe joints. The extension piece of the hydrant shall be of such length that the hydrant barrel bottom flange or top hydrant bury shall be 3" above the top of the sidewalk or curb grade. Apply two coats of paint (OSHA "Yellow" #633). The outlets of all fire hydrants, including operating nuts and threads, shall be as approved by the serving fire department. Apply a field coat of paint to all hydrants after installation.

F. Post indicators: U.L. approved type.

G. Tracer Wire for Non-Metallic Piping: Tracer wire shall be bare copper or aluminum wire not less than 0.10 inch in diameter and shall be provided in sufficient length to be continuous over all runs of non-metallic piping.
H. Pipe bedding and backfill shall conform to requirements of Subsections 306-1.2 and 306-1.3 of the Standard Specifications.

I. Thrust blocks: Portland cement concrete conforming to requirements of Section 03300.

2.2 PIPE WRAPPING

A. Wrap all underground metallic water pipe and fittings with Fiberglass Interwrap, 0.020 inch thick, coated with asphalt enamel, wrapped with 15 pound building felt embedded in hot asphalt, and covered with kraft paper. Joints shall be taped with 20-mil polyethylene tape extended 4 inches over adjacent wrap. An approved proprietary pipe wrap may be submitted for approval.

PART 3 - EXECUTION

3.1 TRENCH EXCAVATION

A. Perform all excavation for the construction of trenches and all additional excavation required for structures forming a part of the pipeline. Trench excavation shall conform to the requirements of Section 306-1 of Standard Specifications. Trenches shall be inspected by the Soils Engineer before proceeding with the work.

3.2 PIPE LAYING, JOINTING AND TESTING

A. Survey line and grade: Grade controls and survey lines shall be provided by a licensed land surveyor obtained by the Contractor.

B. Pipe Installation: Pipe will be inspected in the field by the Inspector of Record before and after laying. Installation of pipe shall conform to the requirements of Section 306-1.2 of the Standard Specifications. Use care not to damage pipe wrapping. Field wrap joints and fittings as the work progresses, comply with manufacturer's recommendations for cleaning surfaces and application of wrapping. Installation of polyvinyl chloride plastic pipe shall also be in accordance with recommendations of pipe and jointing materials manufacturers. Install tracer wire over all non-metallic pipe.

C. Backfill and compaction: Perform in accordance with Section 306-1.3 of the Standard Specifications. In backfilling the trench take all necessary precautions to protect the pipe from any damage or shifting.

D. Testing of pipelines: Perform all tests required by governing agencies. Testing shall be performed in accordance with Section 306-1.4 of Standard Specifications. Furnish all water, materials and labor for making the required tests. All tests shall be made in the presence of the Inspector. Notify the Inspector at least 48 hours before performing the required tests.

E. Install concrete thrust blocks against undisturbed soil at bends, tees, crosses, valves, pipe ends and where changes in pipe diameters occur at reducers or in fittings.

3.3 CONNECTIONS TO EXISTING MAINS

A. Where connections are made between new work and existing mains, the connections shall be made by using special couplings, Rockwell Clamp and Coupling-Tapping Sleeves, or, and other fittings -to suit the on-site conditions. Methods of connections to existing mains shall be as required by local codes.
3.4 HYDROSTATIC TESTING
   A. Test pipeline in accordance with Code and serving water department requirements.

3.5 ACCEPTANCE BY LOCAL GOVERNMENTAL AGENCY
   A. Prior to final acceptance of the work obtain acceptance of the work from the serving utility and submit copies of their certificate or letter of approval to the University.

3.6 STERILIZATION OF MAINS
   A. Sterilization: Before any use of a system is made for domestic purposes, it shall be sterilized with water to which a sterilizing agent has been applied with a minimum of 20 PPM of chlorine to be determined by a residual chlorine test at any part or parts of the line. After the lines have been filled for 24 hours, a residual chlorine test shall show not less than 20 PPM. If less than 20 PPM is indicated, the line shall be flushed and sterilization shall be repeated until a test has indicated a residual of not less than 20 PPM. The line shall then be flushed out until all traces of chemical have been removed.
   B. Flushing of Fire Service Lines: Additional flushing of fire service lines will be required. Such shall be conducted in conformance with the procedures set forth in NFPA Standard 24 (Contained in Vol. 6 of the National Fire Code, Section 98).

3.7 CLEANUP
   A. Upon completion of work, leave the site clean and clear of debris and construction materials.

END OF SECTION 02660
SECTION 02720 – STORM DRAINS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 1 applies to this Section. Provide storm drains, complete as indicated, specified, and required.

B. Work In This Section: Principal items include:
   1. Storm drain pipe and fittings.
   2. Extensions of storm drains through curbs, or to existing storm drain lines, as applicable.
   3. Trenching, backfilling and compaction for storm drain system.

1.2 SUBMITTALS

A. Submittal: List of material proposed to use accompanied by manufacturer's latest printed literature with technical data.

B. Certificates: Manufacturers' certification that materials meet specified requirements.

1.3 RECORD DRAWINGS

A. Provide complete record drawings showing dimensioned locations and depths of all piping, and exact locations off all accessories.

1.4 INSPECTION AND TESTING

A. Refer to Division 1 for procedures.

B. Inspection: Soils Engineer will inspect and test the backfilling work of this section. Notify Soils Engineer prior to commencement of work.

C. Testing: Soils Engineer will make tests to determine degree of compaction in accordance with the following ASTM test methods:

D. Report: Soils Engineer will submit a written report that trenches were backfilled with acceptable material, and that compaction meets the requirements of these specifications.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Cast iron pipe shall be used where indicated and where storm drain lines are within 5 feet of walls and where lines have less than 12 inches of cover.
2.2 DRAINAGE STRUCTURES

A. Construct catch basins other drainage structures at locations, and to the design and dimensions indicated. Exposed concrete work shall have a smooth troweled finish with rounded corners and edges finished plumb and true. Provide grates, frames and covers for catch basins as detailed and indicated.

B. Concrete for catch basins and other drainage structures shall be 3,000 psi concrete at 28 days.

C. Forms for concrete drainage structures shall be rigid and substantial. Plywood or tongue and grooved lumber shall be used for forming the exposed faces of all concrete drainage structures. The top surfaces of the concrete shall be finished by bringing mortar to the surface by tamping, troweling smooth and tooling the edges.

D. Forms shall be kept in place not less than five days after placing, unless otherwise directed or approved. Concrete work shall be cured by keeping it continuously wet for not less than seven days after placing.

2.3 IDENTIFICATION

A. Metallic-Lined Plastic Underground Warning Tapes: Polyethylene plastic tape with metallic core, 6 inches wide by 4 mils thick, solid green in color with continuously printed caption in black letters "CAUTION - STORM DRAIN LINE BURIED BELOW."

PART 3 - EXECUTION

3.1 TRENCHING

A. Excavate trenches per requirements stated in paragraph below. Accurately shape and thoroughly compact trench bottom to grade. Excavate joint space when bells are used, so that the lowest 1/3 of all pipe has firm bearing for its entire length. Lay pipe to lines and grades indicated with sections close jointed to form a smooth flow line. Keep trenches clean until installed work has been approved.

B. Bedding material shall be clean sand extending from 6 inches thick beneath pipe to 12 inches above top of pipe. Place sand simultaneously on each side of the pipe, and thoroughly compact to provide lateral support for the line. Place remaining backfill in 6-inch layers above top of bedding material, moisten as required and compact with hand or pneumatic tampers. Compacting by flooding is prohibited.

C. Compaction shall be performed and comply with the related requirements of Section 02200.
3.2 LAYING PIPE AND JOINTS

A. Lay bell, hub or groove ends up-grade; accurately center the following spigots in them.

B. Polyvinyl Chloride Pipe: Join and install PVC pipe using solvent cement joint pipe and fittings, joining with solvent cement in accordance with ASTM D 2855 and ASTM F 402. Pipe with gasketed fittings shall be joined with elastomeric seals in accordance with ASTM D 3212.

C. Unless otherwise indicated, lateral connections to main lines and angles in lines shall be made with the use of 45-degree wyes.

3.3 SPECIFIC ITEMS

A. Installation of Identification: Install continuous metallic underground warning tape during back filling of trench for underground plastic piping for pipe sizes 12” and larger. Locate 6 to 8 inches below finished grade, directly over piping.

B. Protection: Comply with requirements of Division 1, and as follows:
   1. Provide adequate cribbing, sheathing and shoring as necessary to retain the earth sides of all excavations and trenches from caving and other damage resulting from excavating, together with suitable forms of protection against property damage and bodily injury to personnel employed on the work and the general public. The design, installation and maintenance of required cribbing and shoring shall be the responsibility of the Contractor and shall conform to requirements of the State Division of Industrial Safety and the local governing agencies.
   2. Furnish and maintain all temporary barricades, warning lights, and other types of protection and prevent accidental injury to the general public and all personnel employed on the project.
   3. Drain lines, including trenches, shall be protected from damage during the construction period. Contractor shall replace or rework any damaged portion of the work at no additional cost to the Owner until time of final acceptance of project.

C. Clean-Up. Upon completion of the work, all storm drain systems shall be left free from silt, debris and obstructions.

END OF SECTION 02720
SECTION 02730 – SANITARY SEWER

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 1 applies to this Section. Provide sanitary sewer as indicated, specified, and required.

B. This section specifies sanitary sewer pipe and fittings, lateral services extended to 5-feet from building, connections of laterals to existing mains or municipal sewer system, connection of building sewer system to laterals 5-feet from building, trenching, backfilling and compaction for sewer system.

1.2 SUBMITTALS

A. Layout Drawings: Submit drawings for layout of piping systems. Indicate locations of fittings and other accessories on layout drawings; detail cleanouts. Do not deliver pipe, fittings, and accessories until layout drawings have been approved.

B. Shop Drawings: Submit shop drawings for the following:
   1. Metal work.
   2. Concrete reinforcement in accordance with ACI 315.

C. Manufacturer's Data: Submit manufacturer's standard drawings or catalog cuts of the following items:
   1. Fittings.
   2. Joints and Couplings.
   3. Piping.

D. Standards Compliance: Submit manufacturer's certificates of conformance or compliance for each of the following materials which are specified to conform to publications referenced under paragraph "Materials" in this section:
   1. Pipe and fittings, including factory-applied linings.
   2. Pipe joint materials.
   3. Cast iron frames, covers, and gratings.
   4. Concrete aggregates.
   5. Concrete admixtures.

1.3 QUALITY CONTROL

A. All tests required by the applicable referenced publications shall have been performed, whether specified in that publication to be mandatory or otherwise. For tests which are not specified in the referenced publication to be performed at definite intervals, during manufacture, the tests shall have been performed within three years of the date of submittal of certificates on the same type, class, grade, and size of material as is being provided for the project.

1.4 RECORD DRAWINGS

A. Provide complete record drawings showing dimensioned locations and depths of all piping, and exact locations of all accessories.
1.5 INSPECTION AND TESTING

A. Refer to Division 1 for procedures.

B. Inspection: Soils Engineer will inspect and test the backfilling work of this section. Notify Soils Engineer prior to commencement of work.

C. Testing: Soils Engineer will make tests to determine degree of compaction in accordance with the following ASTM test methods:

D. Report: Soils Engineer will submit a written report that trenches were backfilled with acceptable material, and that compaction meets the requirements of these specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Polyvinyl-Chloride (PVC) Plastic Piping: Conform to ASTM D3033 or D3034, shall be SDR 35, with ends suitable for elastomeric gasket joints.

B. Pipe jointing materials for polyvinyl chloride plastic piping: Joints shall conform to ASTM D3212. Gaskets shall conform to ASTM F477.

C. Concrete Materials: Concrete materials shall be as specified in Section, "Cast-in-Place Concrete."

D. Frames, Covers, and Gratings: Frames, covers, and gratings shall conform to Federal Specification RR-F-621 and shall be of cast iron; figure numbers shall be as shown on the sketches accompanying this section as indicated.

E. Cleanouts: in accordance with the drawings, of the sizes and at locations indicated.

PART 3 - EXECUTION

3.1 TRENCHING EXCAVATION

A. Perform all excavation for the construction of trenches and all additional excavation required for structures forming a part of the pipeline. Trench excavation shall conform to the requirements of Section 02200. Trenches shall be inspected by the Soils Engineer before proceeding with the work.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Location of Piping: Where the location of the sewer is not clearly defined by dimensions on the drawings, lay sewer line not closer horizontally than 10 feet from a water main or service line. Where sanitary sewer lines pass above water lines, encase sewer in concrete for a distance of 10 feet on each side of the crossing, or substitute rubber-gasket pressure pipe for the pipe being used for the same distance. Where sanitary sewer lines pass below water lines, lay pipe so that no joint in the sewer line will be closer than 3 feet, horizontal distance, to the water line. Install a continuous length of tracer wire for the full length of
nonmetallic pressure pipe. Attach wire to top of pipe in such a manner that it will not be displaced during construction operations.

B. Survey line and grade: Grade controls and survey lines shall be provided by a licensed land surveyor obtained by the Contractor.

C. Pipe Laying and Jointing: Each pipe and fitting will be inspected before and after installation and those found defective will be rejected. Provide proper facilities for lowering sections of pipe into trenches. Lay non-pressure pipe with the bell or groove ends in the upgrade direction. Adjust spigots in bells and tongues in grooves to give a uniform space all around. Blocking or wedging between bells and spigots or tongues and grooves will not be permitted. Replace by one of the proper dimensions any pipe or fitting that does not allow sufficient space for proper caulking or installation of joint material. At the end of each day's work, close open ends of pipe temporarily with wood blocks or bulkheads.

D. Connections to Existing Lines: Make connections to existing lines in an approved manner. Conduct work so that there is minimum interruption of service to existing line.

3.3 INSTALLATION OF PVC PLASTIC PIPING

A. Install pipe and fittings in accordance with the general requirements for installation of pipelines and with the requirements of UNI-B-5 for laying and joining pipe and fittings. Make joints with the gaskets previously specified for joints with this piping; assemble these joints in accordance with the requirements of UNI-B-5 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.4 METAL WORK

A. Workmanship and Finish: Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blowholes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary.

B. Field Painting: After installation, clean cast-iron frames, covers, and gratings of mortar, rust, grease, dirt, and other deleterious materials and give a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.5 BACKFILL AND COMPACTION

A. Perform in accordance with requirements of Section 02200. In back-filling the trench, take all necessary precautions to protect the pipe from damage or shifting.

3.6 CONNECTIONS TO EXISTING MAINS

A. Where connections are made between proposed and existing mains, a new manhole will be installed along the existing sewer alignment. See City of Bakersfield for manhole standards. Where connections are made between proposed sewer laterals and existing mains, the connections shall be made by using saddle connections as specified in the City of Bakersfield standards. Methods of connections to existing mains shall be as required by local codes.
3.7 FIELD TESTS AND SURVEYS

A. General: Conduct field tests in presence of the University Representative, as specified herein.

1. Pipelines: Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line.
   a. Leakage Tests: Test lines for leakage by exfiltration test. Fill the line to be tested with water so that the head will be at least 4 feet above top of pipe at upper end of pipeline section being tested. Allow filled pipeline to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, re-establish the head and measure amount of water needed to maintain this water level during a two-hour test period. Amount of leakage, as measured by either infiltration or exfiltration test shall not exceed 0.2 gallon per inch of diameter per hour per 100 feet of pipeline. When leakage exceeds the amount specified, make satisfactory correction and retest pipeline section in the same manner as previously specified. Correct all visible leaks regardless of leakage test results.
   b. Deflection Testing: Make a deflection test an entire length of installed plastic pipeline on completion of all work adjacent to and over the pipeline, including leakage tests, backfilling, or placement of fill, grading, paving, concreting, or any other superimposed loads. Deflection of pipe in the installed pipeline under all external loads shall not exceed 4.5 percent of the normal inside diameter of pipe. Testing may be by either pull-through device or deflection measuring device.

3.8 CLEANUP

A. Upon completion of work, leave the site clean and clear of debris and construction materials.
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies exterior concrete pavement, which include curbs and gutters, walkways, ramps, stairs.

1.2 SUBMITTALS
A. Product Data: Submit for each type of manufactured material and product indicated.
B. Design Mixes: For each concrete pavement mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1.3 QUALITY ASSURANCE
A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
   1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings."
   2. ACI 318, "Building Code Requirements for Reinforced Concrete."
B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
C. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
D. Concrete Testing Service: Engage a qualified independent testing agency to design concrete mixes.

PART 2 - PRODUCTS

2.1 FORMS
A. Forms: Metal, wood, or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal and to provide full-depth, continuous straight, smooth exposed surfaces.
   1. Use flexible or curved forms to form radius bends as required.
B. Form Release Agent: Provide commercial formulation form-release agent complying with local volatile organic compound (VOC) limitations, that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
2.2 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615, Grade 40, deformed.


C. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars to length with ends square and free of burrs.

D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI’s “Manual of Standard Practice” from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project.

B. Portland Cement, ASTM C 150 Type I or II.

C. Aggregate: ASTM C 33, uniformly graded, from a single source, with coarse aggregate as follows:
1. Class: IN
3. Do not use fine or coarse aggregates containing substances that cause spalling.

D. Water: ASTM C94.

2.4 ADMIXTURES

A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures.


C. Water-Reducing Admixture: ASTM C 494, Type A.

2.5 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, non-staining, reinforced, waterproof sheet.

B. Water: Potalbe.

C. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, non-yellowing, wax free. Loss of water in the water retention test shall not exceed 0.040-gram per square centimeter of surface. Deliver curing compound in unopened labeled containers.
1. Provide material with maximum volatile organic compound (VOC) rating of 120 g/L.
2.6  RELATED MATERIALS

A.  Control Joint Material:
   1.  Preformed Fiber Joint Filler: ASTM D1751 non-extruding preformed bituminous saturated fiberboard units. Plain or punched for dowels as required.

B.  Bonding Agent: ASTM C 1059, Type II, Acrylic emulsion or styrene butadiene.

2.7  CONCRETE MIXES

A.  Prepare design mixes for each type and strength of normal-weight concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use a qualified independent testing agency for preparing and reporting proposed mix designs.
   1.  Do not use the University’s field quality-control testing agency as the independent testing agency.
   2.  Limit use of fly ash to 15 percent of cement content by weight.

B.  Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight concrete with the following properties:
   2.  Slump Range: 3 inches to 4 inches.

C.  Add air-entraining admixture at manufacturer’s prescribed rate to result in concrete at point of placement having an air content of 2.5 to 4.5 percent.

2.8  CONCRETE MIXING

A.  Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.

B.  Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.
   1.  When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1  SURFACE PREPARATION

A.  Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and subbase is ready to receive paving.

B.  Remove loose material from compacted subbase surface immediately before placing concrete.

3.2  EDGE FORMS AND SCREED CONSTRUCTION

A.  Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
B. Check completed formwork and screeds for grade and alignment to following tolerances:
   1. Top of Forms: Not more than 1/8 inch in 10 feet.
   2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.

C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.3 PLACING REINFORCEMENT

A. General: Follow CRSI’s recommended practice for "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

3.4 JOINTS

A. General: Construct control, construction, and expansion joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
   1. When joining existing paving, place transverse joints to align with previously placed joints, unless indicated otherwise.

B. Tooled Control Joints (CJ):
   1. Form tooled control joints after initial floating by grooving and finishing each edge of joint with groover tool to the following radius. Repeat grooving of control joints after applying surface finishes. Eliminate tool marks on concrete surfaces.
   2. Jointer Tool: 1/4 inch wide at surface, tapered, with top edges rounded to 1/4 inch radius.
   3. Location: As shown on drawings, but in any case not more than 15 feet o.c. both ways. Typical sidewalk joints shall be 5 feet o.c. or as directed by University Representative.

C. Sawed Joints:
   1. Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8 inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
   2. Prior approval of University Representative is required.

D. Edging:
   1. Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to the following radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.
   2. Radius: As indicated.

E. Construction Joints:
   1. Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour, unless paving terminates at isolation joints.
   2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
   3. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.
F. **Expansion Joints (E.J.):**

1. Form expansion joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
2. Locate expansion joints at intervals of 30 feet, unless indicated otherwise.
3. Extend joint fillers full width and depth of joint, not less than 1/2 inch or more than 1 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.
4. Furnish joint fillers in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together. Do not leave gaps between ends of joint filler units.
5. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
6. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one half of dowel length to prevent concrete bonding to one side of joint.

3.5 **CONCRETE PLACEMENT**

A. **Inspection:** Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. **Moisten subbase** to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

C. **Comply with requirements and with ACI 304R for measuring, mixing, transporting, and placing concrete.**

D. **Deposit and spread concrete in a continuous operation between transverse joints.** Do not push or drag concrete into place or use vibrators to move concrete into place.

   1. When concrete placing is interrupted for more than 1/2 hour, place a construction joint.

E. **Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping.** Use equipment and procedures to consolidate concrete complying with ACI 309R.

   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.

F. **Screed paved surfaces with a straightedge and strike off.** Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.

G. **Hot-Weather Placement:** Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:

   1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor’s option.

   2. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

   3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.
3.6 CONCRETE FINISHING

A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.

B. Float Finish: Begin floating when bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture.

C. Medium Textured Broom Finish: For slopes less than 6%, provide a medium texture by drawing a soft bristle broom across concrete surface perpendicular to line of traffic to provide a uniform fine line texture finish.

D. Heavy (Coarse) Textured Broom Finish: For slopes 6% and greater, provide a coarse finish by straiting surface 1/16 inch to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.7 CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer’s written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

E. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer’s written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.8 FIELD QUALITY CONTROL

A. Testing Services: Testing shall be performed according to the following requirements:
1. Sampling Fresh Concrete: Representative samples of fresh concrete shall be obtained according to ASTM C 172, except modified for slump to comply with ASTM C 94.

2. Slump Tests: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.

3. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.

4. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test, but not less than one test for each day's pour of each type of air-entrained concrete.

5. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each set of compressive-strength specimens.

6. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.

7. When frequency of testing will provide fewer than five compressive-strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

8. When total quantity of a given class of concrete is less than 50 cu. yd., University Representative may waive compressive-strength testing if adequate evidence of satisfactory strength is provided.

9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.

10. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive compressive-strength test results equal or exceed specified compressive strength and no individual compressive-strength test result falls below specified compressive strength by more than 500 psi.

11. Test results shall be reported in writing to University Representative, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7 and 28 day tests.

12. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by University Representative but will not be used as the sole basis for approval or rejection.

13. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by University Representative. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.9 REPAIRS AND PROTECTIONS

A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet requirements of this Section.

B. Drill test cores where directed by University Representative when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
D. Sweep concrete pavement and wash free of stains, discolorations, dirt and other foreign material just prior to final inspection

END OF SECTION 02751
SECTION 03100 – CONCRETE FORMWORK

PART 1 - GENERAL

1.1 SUMMARY
A. Supply and installation of formwork required for all cast-in-place concrete as indicated.

1.2 QUALITY ASSURANCE
A. General: Conform to ACI 347 Chapter 1: Design and Chapter 3: Materials for Formwork.
B. Plywood: Conform to tables for form design and strength in APA Form V 345.

PART 2 - PRODUCTS

2.1 GENERAL
A. Materials shall be new except for reusable joist forms. Materials may be reused during progress of work, provided they are completely cleaned and reconditioned, recoated for each reuse, capable of producing formwork of required quality and are structurally sound.

2.2 MATERIALS
A. Footings, Foundations, Ramps, Landings, Steps and Floor Slabs: Douglas fir "Standard or Better" boards, wood or steel stakes.
B. Studs, Wales, Shoring, Bracing, Centering: "Standard" grade or "Better", Douglas fir, adequate designed size, not less than 2 x 4.
C. Wall Forms: Wall forms shall be 3/4" minimum, Douglas fir plywood, Grade B-B, Class I or II, Exterior, sanded both sides conforming to U.S. Product Standard 1-83. Plywood shall be edge-sealed and oiled both sides with colorless form oil.
D. Forms For Square or Rectangular Columns and Beam and Girder Bottoms: 2" thick Douglas fir planks or joists, S1S2E. Beam and girder sides may be constructed of plywood. Column forms shall be made with tight joints and shall be securely clamped together with steel clamps. Beam and girder sides shall be secured to prevent spreading.
E. Forms For Round Columns: Standard steel or fiber column forms. If columns are to be exposed, use seamless fiber tubes.
F. Concrete Joist Forms: Adjustable type steel pans CRSI standard design or masonite "pres-pan" system.
G. Exposed Concrete Moldings and Ornamental Surfaces: Reverse molded soft pine mould properly placed and secured in forms. Molded surfaces shall be dressed to true, smooth surfaces and oiled. Projecting wood molds shall be constructed to allow proper removal, to avoid fracture of section.
H. Form Oil: Form oil shall be non-staining type, appropriate for use with forms specified and not detrimental to finished concrete surface or applied finish materials.

I. Chamfer Strips: Type CST 3/4" diagonal face, PVC strips.

J. Ties: Carbon steel tie-rods with a breakback depth of 1", and a maximum cone diameter of 1-1/4", or approved equal.

K. Metal Construction Joints: "Keyed-Kold", by Burke Concrete Accessories or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Forms shall be constructed so as to form final concrete structure which conforms to shape, lines and dimensions of members required by Drawings and Specifications, and shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together to maintain position and shape. Forms and their supports shall be designed so that previously placed structures will not be damaged. Forms shall be true to line within 1/250 of the span.

3.2 ERECTION

A. Plywood shall be laid out with horizontal joints level, vertical joints plumb and with all joints tight. Back all joints by studs or solid blocking, and fill where necessary for smoothness. Reused plywood shall be thoroughly cleaned, damaged edges or surfaces repaired and both sides and edges oiled with colorless form oil. Nail plywood along edges, and to intermediate supports, with common wire nails spaced as necessary to maintain alignment and prevent warping.

B. Openings For Cleaning: Provide temporary openings at all points in formwork deemed necessary by the Owner's Representative to facilitate cleaning and inspection. At base of walls and wide piers, bottom form board on one face for entire length shall be omitted until form has been cleaned, inspected and approved. Do not install board until after approval.

3.3 REMOVAL OF FORMS

A. Forms shall not be removed until concrete has hardened sufficiently to maintain its integrity and not be damaged by form removal operations. Columns and walls shall not be stripped in less than 5 days, floor slabs in less than 7 days, beams and girders in less than 15 days. Metal pan forms for joists may be removed after 3 days, but joist centering shall not be removed until after 15 days. Ramp, landing, steps and floor slabs shall not be stripped in less than 7 days. Shoring shall not be removed until member has acquired sufficient strength to support its weight, load upon it, and added load of construction.

B. Compressive strength of in-place concrete shall be determined by testing field-cured specimens representative of concrete location or members, as specified in Section 03300: Cast-In-Place Concrete.

END OF SECTION 03100
SECTION 03200 – CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 SUMMARY
   A. Supply and install concrete steel reinforcement as indicated.

1.2 SUBMITTALS
   A. Submit in accordance with Section 01340: Shop drawings, product data and samples.

1.3 QUALITY ASSURANCE
   A. All materials for the work under this Section shall comply with the following standards:
      4. American Concrete Institute (ACI).
      6. Fabrication and placement of reinforcing shall be in accordance with requirements of Title 24, Part 2, Chapter 19A, California Code of Regulations.
   B. For testing and inspection requirements, see Section 01405: Testing and Inspection.

1.4 PRODUCT HANDLING
   A. Reinforcing steel bars, wire, and wire fabric shall be stored on site to permit easy access for proper examination and identification of each shipment. Material of each shipment shall be separated for size and shape in a manner approved by the University Inspector.
   B. Protect reinforcing from excessive rusting or coating with grease, oil, dirt or other objectionable materials.

PART 2 - PRODUCTS

2.1 GENERAL
   A. Provide reinforcing of sizes, gages and lengths indicated, bent to indicated shapes.
   B. Materials
      1. Steel Reinforcing Bars: ASTM A615 deformed or smooth as indicated, grade 60 billet steel unless otherwise specified or indicated. ASTM 706 deformed bars where welding is required or where specified. Field bending of grade 60 bars is not allowed.
      2. Bars or Rod Mats: ASTM A184.
      3. Steel Wire For Concrete: ASTM A82 (smooth).
PART 3 - EXECUTION

3.1 INSTALLATION

A. Bars shall be bent cold. Bars partially embedded in concrete shall not be field bent except as indicated on approved shop drawings. Before placing, clean reinforcing of loose scale, rust, oil, dirt and any coating that would destroy or reduce bond.

B. Accurately position and secure reinforcing in place as indicated and specified. Secure reinforcing so that it will not be displaced while placing concrete.

C. Use metal chairs to hold reinforcement the proper distance above form bottoms. In beams and slab construction, use chairs under top slab reinforcement as well as under bottom reinforcement. Space chairs so that reinforcement will not be displaced under a person's weight.

D. Use metal spacers to secure proper spacing. Stirrups shall be accurately and securely wired to bars at both top and bottom. At slabs, footings, and beams in contact with earth, use concrete blocks to support reinforcement at proper distance above earth.

E. Place and secure reinforcement to maintain proper clearance between parallel bars, and between bars and forms. Lapped splices shall be made wherever possible in a manner to provide proper clearance between sets of bars. Lapped splices shall in general be staggered. Dowels and bars extending through construction joints shall be secured in position against displacement before concrete is placed, and shall be cleaned of concrete adhering thereto immediately after completion of pour while concrete encrustations are still soft.

F. Do not place reinforcing in supported slabs and beams until walls and columns have been poured to underside of slabs and beams, nor until construction joints have been thoroughly cleaned.

G. Reinforcing shall be checked before concrete is placed and cleaned again if required.

H. Use deformed bars everywhere except for spiral reinforcement and where Drawings or Specifications specifically call for plain or smooth reinforcement to be used.

3.2 FABRICATION

A. CRSI & ACI315 &ACI318

B. Weld Reinforcement – AWS D1.4

END OF SECTION 03200
SECTION 03300 – CAST IN PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Supply and install Cast-In-Place Concrete as indicated.

1.2 REFERENCES

A. Standard references shall conform to current edition of following specifications relating to work of this Section. Chapter 19A CBC, UBC Standard No. 19-1, No. 19-4.

B. American Concrete Institute (ACI) Publication:
   1. ACI 211 "Recommended Practice for Selecting Proportions of Concrete".
   2. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete."
   3. ACI 305 "Recommended Practice for Hot Weather Concreting".
   4. ACI 306 "Recommended Practice for Cold Weather Concreting." 
   5. ACI 308 "Recommended Practice for Curing Concrete."
   6. ACI 309 "Recommended Practice for Consolidation of Concrete."

C. American Society for Testing and Materials (ASTM) Standards:
   1. A185 "Welded Steel Wire Fabric For Concrete Reinforcement."
   2. C31 "Standard Method of Making and Curing Concrete Test Specimens in the Field."
   4. C39 "Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens."
   5. C88 "Standard Method of Test for Soundness of Aggregates by use of Sulphate or Magnesium Sulphate."
   9. C171 "Sheet Materials for Curing Concrete."
   10. C172 "Standard Method of Sampling Freshly Mixed Concrete."
   11. C173 "Standard Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method."
   13. C231 "Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method."

1.3 SUBMITTALS

A. Submit in accordance with Section 01340: Submittals.
   1. Mix Design: Testing laboratory designated by the Owner shall submit a concrete mix design for each mix that will be used on job. Include water/ cement ratio, size of coarse aggregate and
amount of any admixture. Predict minimum compressive strength, maximum slump and air content percentage. Mix design, see Section 01405: Testing and Inspection.

2. Manufacturer of ready-mixed concrete shall deliver to the DSA Inspector a certificate with each mixer truck. Certificate shall bear the signature of representative of the testing laboratory, and shall state quantity of cement, water, fine and coarse aggregate and admixture, if any, contained in load.

3. Certificates: Submit a notarized certificate that each of following conform to standards indicated:
   b. Admixtures - ASTM Standards.
   c. Curing materials - ASTM Standards.

1.4 QUALITY ASSURANCE

A. Continuous inspection shall be maintained at batch plant, see Section 01405: Testing and Inspection, and for transit-mixed concrete to run check sieve analysis of aggregate, check moisture content of fine aggregate, check design of mix, check cement being used with test reports, check loading of mixer trucks, and certify to quantities of materials placed in each mixer truck.

B. Inspection shall be made by a representative of a Testing Laboratory selected by the Owner. The Owner will pay for inspection costs. Contractor shall notify the Laboratory 24 hours in advance of time concrete is to be mixed, and shall promptly notify the Laboratory of postponement or cancellation of mixing. Contractor shall reimburse the Owner for costs incurred resulting from failure to give adequate notification of postponement or cancellation.

C. Continuous batch plant inspection requirement may be waived, see Section 01405: Testing and Inspection. Such waiver shall be in writing, with approval of the DSA.

D. Strength test of concrete, see Section 01405: Testing and Inspection.

1.5 PRODUCT HANDLING

A. Mixing and placing concrete, see Section 01405: Testing and Inspection.

B. Ready mix concrete shall be mixed and delivered in accordance with ASTM C94 and UBC Standard 19-3 and 19-4. Each batch of concrete delivered at job site shall be accompanied by a time slip bearing departure time and signature of batch plant supervisor. Concrete shall be placed within 90 minutes after start of mixing.

C. Store cement and aggregate materials so as to prevent their deterioration or intrusion by foreign matter. Deteriorated or contaminated materials shall not be used for concrete.

1.6 JOB CONDITIONS

A. Hot Weather Requirements: During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection and curing, to prevent excessive concrete temperatures or water evaporation which would impair required strength or serviceability.
PART 2 - PRODUCTS

2.1 GENERAL

A. Ready-Mixed Concrete: Mix and deliver in accordance with requirements of UBC Standard No. 19-13, Ready-Mix Concrete.

B. Strength of Concrete: All concrete, unless otherwise indicated or specified, shall have a minimum ultimate 28 day strength as specified on Structural Drawing Sheet S100. For high-early-strength concrete, age for reaching the f'c shall be indicated on Drawings.

2.2 MATERIALS

A. Cement: "Standard Specification for Portland Cement" ASTM C150. Cement used shall correspond to that on which selection of concrete proportions was based.

B. Aggregates: Aggregates shall conform to "Standard Specification for Concrete Aggregate", ASTM C33 and C227 except as modified herein. Any suitable individual grading of coarse aggregate may be used, provided Grading of Combined Aggregate indicated in following table is obtained: (Refer to Section 01405: Testing and Inspection.)

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<th>Sieve Number or Size in Inches</th>
<th>1-1/2&quot;</th>
<th>1&quot;</th>
<th>3/4&quot;</th>
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<tr>
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C. Water: Water shall be potable and free from deleterious matter. Comply with ASTM C94.

D. Admixtures: Concrete admixture, see Section 01405: Testing and Inspection.


F. Curing Paper and Liquid Curing Compounds:
ART CENTER AND SATELLITE COOLING PLANT  
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD  
BAKERSFIELD, CA

G. Floor Hardener: Mineral or metallic hardener, natural gray color. Floor hardener shall be one of following:
   1. "Lithochrome" of L.M. Scofield Co., Los Angeles, California.
   2. "Colorcron" or "Masterplate", Master Builders.
   4. "Harcol" or Ferrolith "H", Sonneborn Building Products.

H. Abrasive: Aluminum Oxide grain, uniformly graded, screen size 12-13 or 16-30, "Alundum" or "Aloxite."

2.3 PATCHING MATERIAL

A. Bonding Agent:
   1. Acrylic Bondcrete; The Burke Co.
   2. Daraweld; W.R. Grace & Co.
   4. Sonneborn Sonocrete; Chemrex.


PART 3 - EXECUTION

3.1 GENERAL

A. Time of Placing: Do not place concrete until reinforcement, conduits, outlet boxes, anchors, hangers, sleeves, bolts, and other embedded materials are securely and properly fastened in proper positions. Reinforcement and forms shall be examined by the University Representative 24 hours before concrete is placed.

B. Pouring Record: A record shall be kept on site of time and date of placing concrete in each portion of structure. Such record shall be kept until completion of structure and shall be available for examination by the University Representative.

3.2 PREPARATION

A. Reglets and Rebates:
   1. Form reglets and rebates in concrete to receive flashing, frames and other equipment as detailed and required. Dimension and position of required reglets and rebates shall be verified with trades whose work is related thereto.

B. Screeds: Set screeds accurately and maintain at required grade or slab elevations after steel reinforcement has been placed, but before starting to place concrete. Set screeds adjacent to all walls and in parallel rows not to exceed 8'-0" on centers.
3.3 INSTALLATION

A. Conveying and Placing:
1. Concrete shall be placed only under direct supervision of the Inspector. Do not place concrete outside of regular working hours, unless the Inspector has been notified at least 48 hours in advance and is present.
2. Concrete shall be conveyed from mixer to place of final deposit by methods which will prevent separation or loss of materials.
3. Concrete shall be deposited as nearly as practicable to its final position to avoid segregation due to rehandling or flowing. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited, nor shall retempered concrete or concrete which has been remixed after initial set be used.
4. In depositing concrete in columns, walls or thin sections of considerable height, openings in forms, elephant trunks, tremies or other approved devices, shall be placed in a manner that will prevent segregation and accumulation of hardened concrete on forms or metal reinforcement above level of concrete. Such devices shall be so installed that concrete will be dropped vertically. Unconfined vertical drop of concrete from end of such devices to placement surface shall be no greater than 6'-0".
5. Once concrete placing is started, it shall be carried on as a continuous operation until placing of panel or section is completed. Top surfaces of vertically formed lifts shall be level.
6. All concrete shall be thoroughly consolidated during placement, and shall be worked around reinforcement and embedded fixtures using mechanical vibrators.
7. Where conditions make consolidation difficult, or where reinforcement is congested, batches of mortar containing same proportions of cement, sand, and water as used in the concrete, shall first be deposited in the forms to a depth of at least 1".

B. Compaction and Screeding:
1. Tamp freshly placed concrete with a heavy tamper until at least 3/8" of mortar is brought to surface. Concrete shall then be tamped with a light tamper and screeded with heavy straightedge until all depressions and irregularities are worked out, and surface is true to finish grades or elevations. Remove excess water and debris worked to surface.
2. Where slabs are to receive separate cement finish or mortar setting bed, continued tamping to raise mortar to surface shall not be done. Laitance shall be removed by brushing with a stiff brush or by light sandblasting to expose clean top surface of coarse aggregate.

C. Floating and Troweling:
1. When concrete has hardened sufficiently, it shall be floated to a compact and smooth surface. After floating, wait until concrete has reached proper consistency before troweling. Top surfaces, shall receive not less than 2 troweling operations with steel hand trowel. Prior to and during final troweling, apply a fine mist of water frequently with an atomizing type fog sprayer. Omit troweling for slabs to receive a separate cement finish.
2. For interior finish slabs, final troweling shall produce hard, impervious, and nonslip surfaces, free from defects and blemishes. Finished surface shall contact a 10'-0" straightedge for its entire length. A maximum of 1/8” tolerance will be permitted. Sprinkling a mixture of dry cement and sand on concrete slab to absorb surface moisture will not be permitted. Burnishing which produces smooth, slick surfaces, shall be avoided.
3. Vertical concrete surfaces shall be finished smooth and free from marks.

D. Curing:
1. Concrete shall be maintained above 50° F., and in a moist condition for at least the first 7 days after placing, except that high early strength concrete shall be maintained in such a condition for at least the first 3 days.
2. Before applying curing paper, interior floor treated with colored hardener shall be given a heavy protective coat of colored wax left unpolished, and then immediately covered with paper. If wax
is not applied within two hours after final troweling, concrete shall be sprayed with a fine water mist and kept continuously moist until wax is applied, unless spraying is not recommended by hardener manufacturer. After all other work, including plastering and painting has been completed, curing paper shall be removed and waxed floors cleaned of protective wax coating. Clean all floors to their original condition.

3. Forms containing concrete, top of concrete between forms, and all exposed concrete surfaces after removal of forms shall be maintained in a thoroughly wet condition for not less than 7 consecutive days after placing.

4. If weather is hot or surface has dried out, spray surface of concrete slabs and paving with fine mist of water, starting not later than 2 hours after final troweling and continuing until sunset. Surface of finish shall be kept continuously wet until curing medium has been applied.

5. Immediately after finishing, roof slabs and monolithic floor finish to receive resilient floor covering, shall be uniformly and completely coated with liquid curing compound.
   a. Apply compound in a manner and quantity sufficient to produce a uniform continuous thin film of water-impervious membrane. Compound shall be applied in accordance with manufacturer's directions.
   b. Protect adjoining surfaces from damage during application. If curing compound is not applied immediately, cover finished concrete with wet burlap or curing paper and keep concrete surface wet for a period not to exceed thirty hours following finishing of concrete.
   c. At end of that time burlap or paper shall be removed and curing compound applied as specified above.

6. Immediately after finishing, monolithic floor slabs not to receive resilient floor covering shall be covered with curing paper. Paper shall be lapped 3” at joints and sealed with waterproof sealer. Edges shall be cemented to finish. If paper is torn or damaged during construction operations, it shall be repaired or replaced in manner acceptable to the Inspector. Paper shall be on work site before starting cement finishing, and shall remain in place until permission is given by the Inspector to remove paper.

7. Within 24 hours after finishing, all exterior slabs and paving, and interior slabs to receive cement topping or mortar setting bed shall be covered with sand to depth of 2” and kept thoroughly wet for 7 days. Protection shall be removed when directed by the Inspector, and surfaces washed clean.

E. Filling, Leveling and Patching:
   1. Concrete slabs which have high or low spots and are to receive resilient floor covering or soft floor covering, shall have surfaces repaired. High spots shall be honed, or ground with power-driven machines to required levels. Low spots shall be filled with latex underlayment, applied in strict accordance with manufacturer's printed instructions.
   2. Holes resulting from form ties or sleeve nuts shall be solidly packed completely, through all exterior walls, by pressure grouting with cement grout, as specified. Grouted holes on exposed surfaces shall be screeded off flush and finished to match adjoining surfaces.
   3. Cement Base: Cement base shall be of height, thickness and shape detailed. Base shall be reinforced with 1” mesh, #18 gage, zinc-coated wire fabric. Base finish mixture shall be one volume portland cement, 2 volumes of fine aggregate and one volume pea gravel. Colored cement base, where called for, shall include a chemically-inert mineral oxide pigment in mixture.

3.4 FINISHING

A. Soda and Acid Wash: Concrete surfaces to receive plaster, paint or other finish, and which have been formed by oil coated forms, shall be scrubbed with a solution of 1-1/2 pounds of caustic soda to one gallon of water. All surfaces where smooth wood or waste molds have been used shall be scrubbed with a solution of 20% muriatic acid. As soon as surfaces have been scrubbed, they shall be washed with clean water.
B. **Sacking**: Exposed concrete curbs and walls shall be "sacked" by an application of portland cement grout, floated and rubbed. "Sacking" shall not be carried out until all patching and filling of holes has been performed. Entire "sacking" operation for any continuous area shall be started and completed same day.

1. Mix 1 part portland cement and 1-1/2 parts fine sand with sufficient water to produce a grout having consistency of thick paint. Wet surface of concrete sufficiently to prevent absorption of water from grout. Apply grout uniformly with brushes or spray-gun, then immediately float surface with a cork or other suitable float, scouring wall vigorously.

2. While grout is still plastic, finish surface with a sponge-rubber float, removing all excess grout. Allow surface to dry thoroughly, then rub vigorously with dry burlap to completely remove all dried grout. No visible film or grout shall remain after rubbing with burlap.

C. **Floor Hardener**: All exposed interior concrete floors throughout shall be treated with floor hardener, as specified. Apply hardener after surface of concrete has reached the point where no excess moisture shows, but while it is still plastic. Hardener shall be applied as follows:

1. Gray natural. Hardener: Apply at rate of 20 pounds per 100 square feet of surface for initial application.

2. Hardener shall be evenly distributed and thoroughly floated into surface mortar with a wood float. An additional 20 pounds of hardener, gray, specified as above, shall be applied over each 100 square feet, and troweled to an even surface having uniform color and texture.

D. **Cement Grout and Dry-Pack Concrete**: Cement grout shall be mixed at site and shall be composed of one volume of portland cement and 2-1/2 volumes of fine aggregate. Materials shall be mixed dry and sufficient water added to make mixture flow under its own weight. When grout is used as a "dry-pack concrete", add sufficient water to make a stiff mixture which can be molded into a sphere. At the seismic joints provide epoxy bond between existing and new concrete.

3.5 **EXPANSION AND CONSTRUCTION JOINTS**

A. **Construction Joints**: Details and proposed location of construction joints shall be as indicated on Drawings, located to least impair strength of structure, as directed by the Structural Engineer, in accordance with following:

1. Thoroughly clean contact surface by sand blasting entire surface not earlier than 5 days after initial pour.

2. A mix containing same proportion of sand and cement used in concrete plus a maximum of 50% of coarse aggregate shall be placed to a depth of at least 1" on horizontal joints. Vertical joints shall be wetted and coated with a neat cement grout immediately before placing of new concrete.

3. Should contact surface become coated with earth, sawdust, or deleterious material of any kind after being cleaned, entire surface shall be re-cleaned before applying mix.

B. **Expansion Joints**: Provide expansion joints where indicated in walks and exterior slabs. If joints are not indicated, they shall be spaced approximately 40'-0" apart. Joints shall extend entirely through slab with joint filler in one piece for width of walk or slab. Joint filler shall be 3/8" thick unless otherwise indicated.

C. **Tooled Joints**: Slabs, walks and paving shall be marked into areas as indicated with markings made with a V-grooving tool. Marks shall be round-edged, free from burrs or obstructions, with clean cut angles and shall be straight and true. Walks, if not indicated, shall be marked off into rectangles of not more than 12 square feet and shall have a center marking where more than 5'-0" wide.

3.6 **TESTING**

A. **Molded Cylinder Tests**: See Section 01405: Testing and Inspection
1. The Inspector shall prepare cylinders. Each cylinder shall be dated, given a number, point in structure from which sample was taken, mix design number, mix design strength and result of accompanying slump test noted.

2. Separate tests of molded concrete cylinders taken at same place and time shall be made at age of 7 days and 28 days. A strength test shall be the average of the compressive strength of 2 cylinders, made from the same sample of concrete and tested at 28 days or at test age designated for determination of $f_c$.

3. Test cylinders shall be made at job and stored in testing laboratory in accordance with ASTM C31, and tested in accordance with ASTM C39.

4. At least one test shall be taken per 500 sq. ft. Three tests minimum shall be taken for each new building.

B. Core Test: At request of the Inspector, cores of hardened concrete shall be cut from portions of hardened structures for testing, in accordance with CBC 1905A6.1.1, and ASTM C42.

1. Cores shall be taken at representative places throughout the structure as designated by the Structural Engineer and shall be at least 4" in diameter.

2. In general, sufficient cores shall be taken so that knowledge will be had for all pours made. At least one core shall be taken for each 4000 square feet of building. Not less than 3 cores shall be taken from each project.

3. Where cores have been cut from work, Contractor shall fill void with drypack and patch the finish to match the adjacent existing surfaces.

C. Concrete Consistency: Measure consistency by "Standard Method of Test for Slump of Portland Cement Concrete," ASTM C143. This test shall be made by the Inspector twice each day or partial day's run of the mixer.

D. Adjustment of Mix: Should the strength of any grade of concrete for any portion of work, as indicated by molded test cylinders, fall below minimum 28 days compressive strength specified or indicated, the Structural Engineer will direct the testing laboratory to adjust mix for remaining portion of construction so that resulting concrete meets minimum strength requirements.

E. Defective Concrete:

1. Should strength of any grade of concrete, for any portion of work indicated by tests of molded cylinders and core tests, fall below minimum 28 days strength specified or indicated, concrete will be deemed defective and shall be replaced or adequately strengthened in a manner acceptable to the Structural Engineer, the Inspector and the Division of the State Architect.

2. Any concrete work that is not formed as indicated, is not true within 1/250th of span, not true to intended alignment, not plumb or level where so intended, not true to intended grades and levels, contains sawdust shavings, wood or embedded debris, or does not fully conform to Contract provisions, shall be deemed to be defective and shall be removed and replaced.

F. Concrete For Equipment Pads, Mechanical and Electrical Work: Unless otherwise indicated, strength shall be 3000 psi concrete, proportioned and mixed in accordance with requirements of this Section. Exposed concrete shall have a hand-troweled finish with neatly rounded corners and edges. Cast in forms where necessary as described in Section 03100, Concrete Formwork, and reinforced as described under Section 03200. Calcium chloride shall not be used in concrete mix for underground electrical conduits. For concrete encasement of more than one conduit, use 3/4" to 1" rock as specified in this Section for concrete mix

END OF SECTION 03300
SECTION 04220 – CONCRETE MASONRY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies concrete masonry units.

1.2 RELATED DOCUMENTS

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

1.3 RELATED SECTIONS

A. Section 03300: Cast-in-Place Concrete; furnishing of reinforcing steel for masonry work and placing of dowels in concrete for start of masonry work.

1.4 QUALITY ASSURANCE

A. Testing Laboratory Services: Laboratory selection, payment and reports in conformance with Section 01405. Perform following tests:
   1. Concrete Masonry Units: Sampled and tested in accordance with ASTM C 90 and C 140, and in addition, shall have a maximum linear shrinkage of .06% from the saturated to the oven dry condition.
   2. Cement: Sample and test cement or provide mill test reports.
   3. Mortar and Grout Tests: Comply with Title 24, Part 2, Sec. 2105A.3.4. Take minimum of one set of cylinders on each of first three days of masonry work and at least at one week intervals thereafter.
   4. Cores: Perform core tests on sample masonry work and structure in accordance with Title 24, Part 2, Sec. 2105A.3.1. Location of cores in structure shall be approved by the University Representative.

B. Masonry Inspection: Masonry work will be continuously inspected during laying by an inspector specially approved for that purpose by the University. Cost of such inspection will be paid for by the University.

C. Sample Panel: Build sample panel approximately 4 feet high by 6 feet long, including a corner.
   1. Accepted panel may be part of the Work and incorporated into wall system.
   2. Do not proceed with masonry construction until sample panel is accepted by the Project Engineer.
   3. Use full size masonry units which have been selected and approved by Architect to show color range, maximum texture range, bond, mortar, tooling of joints and quality of workmanship in sample panel.
   4. Retain sample panel on Project for comparison purposes with actual masonry work.
   5. If sample panel is not part of wall system, demolish and remove from site upon completion and acceptance of concrete masonry work.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Split Face Hollow Concrete Masonry Units: ASTM C 90, Grade N1, medium-weight, all black color aggregate with standard cement. Split face texture all exposed faces and ends.
   1. Provide bond beam units at horizontal reinforcing.
   2. Special color in grey tones as selected, using gray cement. Aggregate Color: Black.

B. Split Face Solid Masonry Veneer: ASTM C 145, Grade N1, medium weight. Materials as specified for hollow concrete masonry units. Color to match hollow block units, split face texture one side and exposed ends.

C. Smooth (Precision) Face Hollow Concrete Masonry Units: ASTM C 90, Grade N1, medium weight smooth face, straight edge. Special color in grey tones, to match Architect’s sample.

D. Smooth Face Solid Masonry Veneer Units: ASTM C 90, Grade N1, medium weight. Color and texture to match hollow units.

E. Concrete Masonry Cap Block Units: Provide solid concrete masonry units complying with following:
   1. Comply with ASTM C 90, Grade N1, medium weight.
   2. Provide Smooth (Precision) Face cap block units, nominal 2 by 8 by 16 inches.
   3. Color to match ground face concrete masonry units.

F. Masonry Assembly Strength:
   1. Minimum f’m: 1500 psi at 28 days, unless noted otherwise.

G. Fire Rated Units:
   1. Conform to CBC, Chapter 7, Table 7B, for face-shell thickness and web thickness and for solid block requirements for required fire ratings.

2.2 MORTAR AND GROUT MATERIALS

A. Cement: For mortar and grout: Type I or Type II Portland Cement conforming to ASTM C 150. Type II Portland Cement may be used only if it equals strength of Type I. All cement used (mortar and grout) shall be low alkali type (0.6% maximum).

B. Sand: Sand for mortar shall conform to ASTM C 144, except that not less than 3 per cent of sand shall pass #100 sieve. Sand for grout shall conform to ASTM C 404.

C. Pea Gravel: Conforming to ASTM C 33. Size Range No. 8 to 3/8 inch.

D. Lime: Hydrated lime conforming to ASTM C 207, Type S.

E. Water: From a potable source.

F. High Lift Grout Admixture: Sika Chemical Corporation “Sika Grout Aid Type II”.

G. Mortar Color Pigment: Davis Colors, Solomon Colors, or approved equal. Color as selected by the University Representative.
2.3 MASONRY ACCESSORIES

A. Wire Reinforcing and Ties for Masonry: 9 gage cold-drawn steel wire complying with ASTM A 82.

2.4 MORTAR AND GROUT MIXES

A. Mixing: Accurately measure materials for mortar and grout in suitably calibrated devices. Measurements based on dry loose volume. Shovel measurements or fractional sack batches not acceptable. Place sand, cement and water, in that order, in mixer and mix for at least two minutes. For mortar, add lime and continue mixing for at least 10 more minutes or as much longer as required to secure a uniform mass. Retempering of mortar is not permitted. Remove from Work any mortar or grout which is unused within one hour after initial mixing.

B. Proportion grout by volume with sufficient water added to produce consistency for pouring without segregation.

C. Do not use calcium chloride in mortar or grout.

D. Mortar: Title 24, Part 2, Sec. 2103A.3.
   1. 1 part portland cement, not less than 2-1/4 to not more than 3 parts sand, not less than 1/4 part nor more than 1/2 part lime.
   2. Strength: Minimum 1,800 psi at 28 days, unless noted otherwise.

E. Grout: Title 24, Part 2, Sec. 2103A.4.
   1. Coarse Grout: 1 part portland cement, 1/10 part hydrated lime, 2-1/4 to 3 parts (times) fine aggregate and 1 to 2 parts (times) coarse aggregate.
   2. Strength: Minimum 2,000 psi at 28 days, unless noted otherwise.

F. Admixtures:
   1. Do not add admixture to mortar unless approved by the University Representative.

PART 3 - EXECUTION

3.1 REINFORCING

A. General: Clean free of loose rust, mill scale, earth, or other materials which will reduce bond to mortar or grout. Do not use reinforcing bars with kinks or bends not shown on drawings or final shop drawings, or bars with reduced cross-section due to excessive rusting or other causes.

B. Position reinforcing accurately at the spacing shown. Support and secure vertical bars against displacement. Horizontal reinforcing may be placed as the masonry work progresses. Where vertical bars are shown in close proximity, provide a clear distance between bars of not less than the nominal bar diameter or 1 inch (whichever is greater).

C. Splice reinforcing bars where shown; do not splice at other points unless acceptable to the Architect. Provide lapped splices, unless otherwise shown. In splicing vertical bars or attaching to dowels, lap ends, place in contact and wire tie.
   1. Provide not less than minimum lap shown, or if not shown, as required by governing code.
   2. Weld splices where shown. Comply with the requirements of AWS D1.4 for welding materials and procedures and with Section 03300 for welded reinforcement.
D. Completely embed all bars in mortar or grout for joint reinforcement embedded in horizontal mortar joints, and provide not less than 5/8 inch mortar coverage on exterior face of walls and 1/2 inch at other locations. For all other reinforcement provide minimum coverage of one bar diameter over all bars, but not less than 3/4 inch except where exposed to weather or soil in which case provide minimum coverage of 2 inches.

3.2 INSTALLATION, GENERAL

A. Lay-up walls plumb and true and with courses level, accurately spaced and coordinated with other work. Lay up masonry so that variations in texture and color will be evenly distributed throughout the masonry work.

B. Clean concrete surfaces receiving first course of masonry by removing entire surface of concrete, exposing clean aggregate.

C. Cut masonry units with motor-driven saw designed to cut masonry with clean sharp, unchipped edges. Cut units as required to provide pattern shown and to fit adjoining work neatly. Use full units without cutting wherever possible.

D. Carry masonry courses up at the same level at wall intersections and corners, or slope back. No toothed joints permitted. Keep core space free of mortar droppings and other debris.

E. Top of walls, piers, parapets and the like not covered shall be filled with grout and troweled smooth.

F. Bond Pattern: Running bond.

G. Joints: Maintain joint widths shown, except for minor variations required to maintain bond alignment. If not otherwise indicated, lay walls with 3/8 inch joints. Cut joints flush for masonry walls which are to be concealed or to be covered by other materials. Tool exposed joints slightly concave. Rake out mortar in preparation for application of calking or sealants where shown.

H. Built-in Work: As the work progresses, build-in items specified under this and other sections of these specifications. Fill in solidly with masonry around built-in items.
   1. Fill space between hollow metal frames and masonry solidly with mortar.
   2. Install reglets and nailers for flashing and other related work where shown to be built into masonry work.
   3. Install bolts, dowels, plates, anchors, hangers and the like where shown to be built into masonry for work of other trades.
   4. Solid grout hollow metal door frames where shown.

I. Weep Holes:
   1. Provide weep holes above flashing.
   2. Form weep holes with waxed rope extending through exterior wythe; remove rope upon completion of masonry work to leave clean hole.
   3. Maintain cavity space completely open and free of mortar.

3.3 GROUTING

A. Vertical cells shall have vertical alignment, to maintain continuous unobstructed vertical cell area of 3 by 3 inches. Grout shall be sufficiently fluid to ensure complete filling of all sections of units, but not so thin as to allow segregation of aggregate.
   1. Grout all cells.
B. In no case shall grout contain more than 7-1/2 gallons of water per sack of cement.

C. Grout pours in excess of 48 inches in height shall be provided with cleanouts.

D. Unless high-lift method is used the maximum lift of grout pour shall be 4 feet.

E. When grouting is stopped for a period of one hour or longer, horizontal construction joints shall be formed by stopping the grout one inch below top of uppermost unit.

F. High lift grout method may be used complying with the following:
   1. Title 24, Part 2, Chapter 21A, Sec. 2104A.6.1.1.3, and 2104A.6.1.2.3.

3.4 MASONRY VENEER OVER STUD FRAMING

A. Anchors: Place anchors in slots at 16 inches on center; fasten with galvanized 16d Box Nail driven in tight behind each anchor. Run continuous 9 gage galvanized steel wire through anchors horizontally; embed in mortar joint.

3.5 CURING

A. Do not saturate with water for curing or any other purpose.

3.6 REPAIR, POINTING AND CLEANING

A. Remove and replace masonry units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in fresh mortar or grout, pointed to eliminate evidence of replacement.

B. Pointing: During the tooling of joints, enlarge any voids or holes, except weep holes, and completely fill with mortar. Point-up all joints at corners, openings and adjacent work to provide a neat, uniform appearance, properly prepared for application of caulking or sealant compounds.

C. Repair of Cores: Neatly patch core holes, restoring walls as nearly as possible to original appearance.

D. Cleaning at Completion: Tuck point holes 1/8 inch or more. Grind off lumps, clean debris and surplus. Leave the masonry clean and free of mortar drops.

END OF SECTION 04220
PART 1 - GENERAL

1.1 SUMMARY

A. Supply and install structural steel as indicated.

1.2 RELATED SECTIONS

A. Section 01400: Quality Control

B. Section 05410: Load Bearing Metal Stud System.

C. Section 05500: Metal Fabrications.

D. Section 09900: Painting.

1.3 SUBMITTALS

A. Submit in accordance with Section 01340: Shop drawings, product data and samples.
   1. Materials Identification Report: A report of material identification, together with identified copies of the mill test reports, shall be submitted to DSA by the Testing Laboratory when manufacturer's mill test reports are used to establish conformity with material specifications.
   2. Shop and Erection Drawings: Submit checked prints of shop and erection drawings for structural steel work.
   3. Record Set of Drawings: After structural steel has been erected and approved shop and erection drawings have been corrected to correspond with changes made in field, submit a complete corrected set of prints.

1.4 QUALITY ASSURANCE

A. Structural steel shall conform to Title 24, except that steel manufactured by acid Bessemer process shall not be used for structural purposes.

B. Sheet and strip steels and steels other than those listed in U.B.C. Standard No. 22-1, if used for structural purpose, shall be specifically approved by the Division of the State Architect.

C. Structural steel used in welded construction shall have the properties suitable for welding.

D. Structural steel shall conform to "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings".

1.5 PRODUCT HANDLING

A. Store structural steel above ground on platforms, skids or other approved supports.
B. Protect steel from corrosion.

C. Store welding electrodes in accordance with AWS D 12.1.

D. Store other materials in a weathertight and dry place, until ready for incorporation into work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Stock Materials: Provide exact materials, sections, shapes, thicknesses, sizes, weights and details of construction indicated on Drawings. Changes because of material stock or shop practices will be considered for approval if net area of shape or section is not reduced thereby, if material and structural properties at least equivalent, and if overall dimensions are not exceeded.

2.2 MATERIALS

A. Structural Steel: Wide flange shapes shall conform to ASTM A992 or ASTM A572 Grade 50.

B. Steel Plates shall conform to ASTM A36.

C. Steel Pipe: ASTM A53 - Type E or S, grade B.

D. Structural Tubing:
   2. Cold-formed, ASTM A500, grade B.

E. Bar Stock for Anchor Bolts: ASTM A36.

F. Machine Bolts and Nuts: ASTM A307, grade A.

G. High Strength Steel Bolts: UBC standard No. 27-7 for high strength bolts.

H. Plain Washers: ANSI B27.2.

I. Galvanizing: ASTM A123.

J. Primer: "Tnemec 99" or approved equal.

2.3 FABRICATION

A. Cleaning and Straightening Materials: All materials being fabricated shall be thoroughly cleaned of all scale and rust, and straightened before being worked on. Cleaning and straightening methods shall not injure material. After punching or working component parts of a member, all twists or bends shall be removed before parts are assembled.

B. Fabricate work in accordance with UBC Standard No. 22-2.
C. Cutting, Punching, Drilling and Tapping: Unless otherwise indicated or specified, structural steel fabricator shall do all cutting, punching, drilling and tapping of his work so that work of other trades will properly connect to steel work.

D. Milling: Compression joints depending on contact bearing shall have bearing surfaces prepared to a common plane by milling.

E. Use of Burning Torch: Oxygen cutting of members shall be done by machine. Gouges greater than 3/16" that remain from cutting shall be removed by grinding. All reentrant corners shall be shaped notch free to a radius of at least 1/2". Gas cutting of holes for bolts or rivets is prohibited.

F. Galvanizing: After fabrication, items indicated or specified to be galvanized shall be galvanized in largest practical sizes. "Fabrication" includes all operations of shearing, punching, bending, forming, assembling or welding. Galvanized items shall be free from projections, barbs or icicles resulting from galvanizing process.

G. Welding:
1. Type of steel used in welded structures shall have chemical properties suitable for welding as determined by chemical analysis. Welds shall conform to the requirements of Title 24.
2. Materials and workmanship shall conform to the requirements specified herein and to UBC Standard No. 22-6, modified as follows:
   a. No welded splices shall be made except those indicated on Drawings unless approved in writing by Structural Engineer.
   b. Drawings will designate joints in which it is important that welding sequence and technique be controlled to minimize shrinkage stresses and distortion.
3. Welding shall be performed in accordance with requirements of the "American Welding Society" (AWS) and "Structural Welding Code."

H. Shop Finish:
1. Notify the owner when work is ready to receive shop red oxide prime coat. Work shall be inspected and approved by the owner before application of primer.
2. Structural steel and fittings, except galvanized items, which will be exposed when building is completed shall receive a coat of primer.
3. The primer specified shall be spray applied, filling all joints and corners and covering all surfaces with a smooth unbroken film. The minimum dry film thickness of the primer shall be 2.0 mils. Follow manufacturer's instructions for thinning.

2.4 QUALITY CONTROL

A. Tests:
1. Structural steel shall be identified in accordance with Title 24, Part 2. The grade and ASTM specification number or designation shall be indicated on each lift or bundle of fabricated elements.
2. If structural steel cannot be identified at least one tension and elongation test and one bend flattening test shall be made for each piece.
3. For castings and forgings, chemical analysis and one tension and elongation test will be required for each heat. Complete four-sided inspection shall be made of all castings.
4. For sheet and strip steel, one tension and elongation test and one bend or flattening test for each 5 tons or fractional part thereof for each size or gage will be required.
5. Test specimens shall be furnished by steel fabricator and taken under direction of the Testing Laboratory to dimensions required by "Standard Methods and Definitions for Mechanical Testing of Steel Products", ASTM A370.
6. Cost of tests of stock will be borne by the District, except that if a test fails to comply with requirements of Specifications, cost of testing shall be borne by Contractor.
7. If after fabrication and inspection, work is found to be defective and requires re-inspection, costs of such re-inspection shall be borne by Contractor.
8. Steel fabricator shall provide all labor, equipment and facilities necessary for moving and handling materials to be inspected.

B. Welding Inspections:
   1. Inspection of all shop and field welding operations shall be made by a qualified Welding Inspector. The welding inspector shall make a systematic record of all welds including:
      a. Identification marks of welders.
      b. List of defective welds.
      c. Manner of correction of defects.
   2. The Welding Inspector shall be notified at least 2 days before shop or field welding inspection is to be required.
   3. The Welding Inspector shall check the material, equipment and procedures, as well as welds and competence of welder. He shall furnish a report that welding which is required to be inspected is proper and has been done in conformity with approved Drawings and Specifications.
   4. The Welding Inspector shall use all means necessary to determine quality of weld and may use gamma ray, magnaflux, trepanning sonics or any other aid to visual inspection deemed necessary to assure adequacy of welding.

C. Inspection of Shop Fabrication: Shall be in accordance with Title 24, indicated in Section 01405: Testing and Inspection.

D. Inspection of High Strength Bolt Installation: Shall be in accordance with Title 24, indicated in Section 01405: Testing and Inspection.

E. Tests of End Welded Studs: End welded studs shall be tested in accordance with Title 24, indicated in Section 01405: Testing and Inspection.

PART 3 - EXECUTION

3.1 VERIFICATION
   A. Verify governing dimensions and conditions at job site before commencing erection work.

3.2 ERECTION
   A. Erect all steel in strict accordance with Drawings, approved shop drawings and all standards.
   B. Where indicated for field connections, standard bolts (ASTM A307), do not require washers under head or under nut, except that beveled washers are required when outer face of the bolted parts have a slope greater than 5%.
   C. Install high strength steel bolts at locations indicated. Assembly and installation shall be in accordance with UBC Standard No. 22-7 "High Strength Bolts”.
   D. Erect structural steel plumb and level and to proper tolerances as set forth in the AISC Manual. Provide all temporary bracing, supports or connections required for complete safety of structure until final permanent connections are made.
E. Set column bases within a tolerance of 1/8" of detailed center lines, and set and level at proper elevations. Support bases on double nuts and solidly fill all spaces under bases with drypack cement grout rammed into place.

3.3 FINISHING

A. After erection, spots or surfaces where paint has been removed, damaged, or burned off and field rivets, bolts, and other field connections not concealed in work, shall be cleaned of dirt, oil, grease, and burned paint and given a spot coat of same primer used for shop priming.

B. Damaged galvanized surfaces shall be coated with Galvalloy, Galvabar or approved equal. Heat damaged surface to approximately 600 degrees fahrenheit. Rub alloy bar over heated surface. Paint is not acceptable.

END OF SECTION 05129
SECTION 05300 – METAL DECKING

PART 1 - GENERAL

1.1 SUMMARY

A. Supply and install Metal Decking as indicated.

1.2 RELATED SECTIONS

A. Section 01405: Testing and Inspection.
B. Structural steel support for Metal Decking; Section 05129: Structural Steel.
C. Section 07600: Flashing and Sheet Metal.

1.3 SUBMITTALS

A. Submit in accordance with Section 01340: Submittals.
   1. Shop drawings shall indicate type of decking, finish, gage of metal, where located, arrangement of sheets, necessary fabrication to incorporate decking into project, and correlation with other required openings and flashings.
   2. Where shop drawings of supporting structural members are required, prepare decking shop drawings using approved shop drawings of supporting members.

1.4 QUALITY ASSURANCE

A. Work of this Section shall be in accordance with California Code of Regulations, Title 24. See Section 01405: Testing and Inspection
B. Quality Welders: Properly certified for the type of work involved in compliance with UBC see Section 01405: Testing and Inspection.
C. Continuous inspection of all welding will be performed by a qualified Welding Inspector, approved by the Division of the State Architect Office of Regulation Services, and as described under Title 24, see Section 01405: Testing and Inspection.
D. Requirements of Regulatory Agencies: Be responsible for obtaining UL certification and approval of the decking when used as a part of an assembly indicated on Drawings in which fire resistive construction ratings are required.
E. Performance Requirements: Compute properties of deck sections on basis of effective design width as limited by provisions of the AISI specifications. Provide not less than deck section properties specified, including section modulus and moment of inertia per foot of width.
1.5 TESTS AND INSPECTIONS

A. General: Metal decking steel shall conform to requirements of strengths and properties of standards specified.

B. Identification of metal decking steel shall conform to the standards specified under Title 24, see Section 01405: Testing and Inspection.
   1. Fabricator shall furnish sufficient evidence to the University Representative attesting to compliance with specified requirements.

C. Unidentifiable Steel: Steel which is not readily identifiable as to grade from markings and test records shall be tested to determine conformity to specified standards.
   1. Contractor shall provide all specimens as part of work of this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer shall be VERCO or equal.

2.2 MATERIALS

A. Metal Decking: Roll-formed sheets conforming to ASTM A446, with ASTM A525, G90 zinc coating.
   1. Section properties shall conform to applicable provisions of latest edition of "Specification for the Design of Cold-Formed Steel Structural Members" as published by the American Iron and Steel Institute.
   2. Refer to Drawings for metal decking requirements.

B. Flexible Closure Strips For Deck: Vulcanized, closed-cell, expanded chloroprene elastomer, complying with ASTM D1056, Grade SCE #41.

C. Metal Flashing and Closures: #22 gage minimum, ASTM A526 with ASTM A525, G90 zinc coating.

2.3 FABRICATION

A. Corrugated sheets or sections shall be designed to support required live load between supporting members.

B. Wherever practical, provide decking in lengths to span over 3 or more supports.

C. Except as detailed otherwise, provide all decking with interlocking side laps, 2-1/2" minimum end bearing, and 1-1/2" minimum side bearing.
PART 3 - EXECUTION

3.1 OPENINGS

A. Cut and reinforce units to provide openings which are located and dimensioned on the Structural and Mechanical Drawings.

B. Provide openings which are required for work of other trades and which are not indicated on Structural or Mechanical Drawings only upon approval of the Structural Engineer as to size, location and reinforcement.
   1. Costs for cutting and reinforcing of such openings shall be chargeable to trade requiring openings.

3.2 ERECTION

A. Erect metal decking in accordance with decking manufacturers' recommendations, requirements of Drawings, Shop Drawings and Specifications.
   1. Decking installation will be inspected by the DSA Inspector who will certify that work has been performed in compliance with Contract Documents.

B. Place metal decking on supporting steel framework and adjust to final position before permanently fastening in place.
   1. Bring each unit to proper bearing on supports.
   2. Place units in straight alignment for entire length of run of cells with close registration of cells of one unit with those of abutting unit.

C. Fasten decking to steel framework at ends of units and at intermediate supports. Welding shall be as indicated on Structural Drawings.

D. Fasten side laps between supports as indicated on Drawings.
   1. Button punch side laps not indicated on Drawings to be welded.

E. Perform field cutting parallel with cells in area between cells, taking care to leave sufficient horizontal material to permit satisfactory welding to supporting steel.

3.3 METAL FLASHINGS AND CLOSURES

A. Furnish, install and weld in position, sheet metal closure flashings, closure angles, closure plates, profile plates and shear plates.

B. Close open ends of cell runs at columns, openings, walls, and similar interruptions and terminations.

END OF SECTION 05300
SECTION 05500 – METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY
A. Supply and install metal fabrications including but not limited to steel pipe, square and rectangular tubing and pipe columns.

1.2 RELATED SECTIONS
A. Section 01400: Quality Control.

1.3 SUBMITTALS
A. Submit in accordance with Section 01340: Shop drawings, product data and samples.
   1. Submit shop drawings indicating materials used, dimensions, anchoring details, and adjacent construction.

1.4 QUALITY ASSURANCE
A. Reference Specifications, Standards and Code:
   1. Design, fabricate and erect miscellaneous metals in accordance with AISC'S Design, Fabrication and Erection of Structural Steel for Buildings.
   2. AWS D-1.0 Code - Welding in Building Construction.
   3. Inspection of Welding: See Section 01400: Quality Control

1.5 PRODUCT HANDLING
A. Store miscellaneous metal items above ground on platforms, skids or other approved supports.
B. Protect metals from corrosion.

PART 2 - PRODUCTS

2.1 MATERIALS
A. Structural Steel Shapes: "Standard Specifications for Structural Steel", ASTM A36, unless noted otherwise.
B. Steel Pipe:
   1. Steel pipe for pipe columns, and other structural purposes shall conform to "Standard Specification for Welded and Seamless Steel Pipe", ASTM A53, Type E or S, Grade B, as required.
2. Steel pipe other than pipe used for structural purposes shall conform to "Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses", ASTM A120, or ASTM A53.

C. Square and Rectangular Steel Tubing:
1. Steel tubing for structural purposes shall be carbon steel conforming to "Standard Specification for Cold-Formed Welded and Seamless Carbon Structural Tubing in Rounds and Shapes" ASTM A500.
2. Steel tubing other than tubing used for structural purposes shall be hot or cold rolled carbon steel electric welded tubing.


F. Rolled steel plates and shapes:
1. Shapes and plates shall conform to ASTM A992 or ASTM A572 Grade 50, except for plates to be bent or cold-formed.
2. Plates to be bent or cold-formed shall conform to ASTM A283, Grade C.

G. Fasteners: Provide zinc-coated fasteners for exterior use or where built into exterior walls. Select fasteners for the type, grade and class required.
1. Bolts and Nuts: Regular hexagon head type, ASTM A 307, Grade A.
2. Lag Bolts: Square head type, ANSI B 18.2.1.

H. Non-Shrink Nonmetallic Grout: Factory pre-mixed, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide one of following or grout specifically recommended by manufacturer for types of applications indicated.
1. Masterflow 713; Master Builders Div., Degussa
2. Five Star Grout; Five Star Products, Inc.
3. SikaGrout 212; Sika Corporation

I. Paint:
1. Shop Primer for Ferrous Metal: Manufacturer's or Fabricator's standard, fast-curing, lead free, "universal" primer; selected for good resistance to normal atmospheric corrosion, for compatibility with finish paint systems indicated and for capability to provide a sound foundation for field-applied topcoats despite prolonged exposure; complying with performance requirements of FS TT-P-645.
2. Coordinate selection of metal primer with finish paint requirements specified in Section 09900.
3. Galvanizing Repair Paint: Organic zinc rich paint complying with SSPC-Paint-20, with dry film containing not less than 94 percent zinc dust by weight.
4. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 except containing no asbestos fibers.
2.2 FABRICATION

A. General:
1. For fabrication of items which will be exposed to view, use only materials which are smooth and free of blemishes. Remove blemishes by grinding or by welding and grinding, prior to cleaning, treating and application of surface finishes including zinc-coatings.
2. Form exposed work true to line and level with accurate angles and surfaces, and straight sharp edges.
3. Ease exposed edges to a radius of approximately 1/32", unless otherwise indicated or specified.
4. Form bent metal corners to the smallest radius possible without causing grain separation or otherwise impairing work.
5. Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners wherever possible.
6. Remove loose rust, mill scale, cutting and punching burrs.
7. Fabricate items in as large sections as practical to minimize field jointing.

B. Metal Ladder: Fabricate ladders for locations shown, with dimensions, spacings, details and anchorages indicated. Comply with requirements of ANSI A14.3, except as otherwise indicated.
1. Unless otherwise shown, provide 1/2 by 2-1/2 inch continuous structural steel flat bar side rails with eased edges, spaced 18 inches apart.
2. Provide 3/4 inch diameter solid structural steel bar rungs, spaced 12 inches o.c.
3. Fit rungs in centerline of side rails, plug weld and grind smooth on outer rail faces.
4. Support each ladder at top and bottom and at intermediate points spaced not more than 5 feet o.c. Use welded or bolted steel brackets, designed for adequate support and anchorage, and to hold ladder clear of wall surface with minimum 7 inch clearance from wall to centerline of rungs. Extend rails 42 inches above top rung, and return rails to wall or structure unless other secure handholds are provided. If adjacent structure does not extend above top rung, goose-neck extended rails back to structure to provide secure ladder access.
5. Hot-dip galvanize all ladders, brackets and fasteners.

C. Miscellaneous Framing and Supports:
1. Fabricate miscellaneous units to sizes, shapes and profiles indicated or, if not indicated, of necessary dimensions to receive adjacent work to be retained by framing.
2. Except as otherwise indicated, space anchors 2'-0" o.c., and provide minimum anchor units of 1-1/4" x 1/4" x 8" steel straps.
3. Shelf angles for exterior construction shall be galvanized steel of sizes indicated.

D. Welding:
1. Weld shop connections and field connections unless, indicated or specified otherwise.
2. Weld corners and seams continuously and in accordance with requirements of Steel.
3. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

E. Galvanizing:
1. Galvanizing shall conform to requirements of ASTM A123, "Standard Specification for Zinc (Hot-galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip".
2. Items to be galvanized shall be hot-dip galvanized in as large sections as possible.

F. Shop Finish:
1. Miscellaneous metal fabrications, except those galvanized items, which will be exposed when building is completed, shall receive a coat of primer.
2. Primer specified shall be spray applied, covering surfaces with a smooth unbroken film. Minimum dry film thickness of primer shall be 2.0 mils.
PART 3 - EXECUTION

3. Preparation for Painting: Miscellaneous ferrous metal, except items specified galvanized or shop primed, shall be thoroughly cleaned of all mill scale, grease, dirt or rust, by scraping, wirebrushing, or sandblasting and shall be delivered to job unpainted, but in proper condition for painting. Shipping oil or other protective coatings shall be removed.

3.1 FINISH

A. Repair of Damaged Galvanized Surfaces: Galvanized finish which has been damaged or burned off in welding shall be repaired by coating surface with "Galvalloy" or "All - State Galvover" or approved equal. Clean surface of foreign matter, heat to approximately 600° F. and rub alloy bar over heated surface, allowing a small amount to flow. Wire brush briskly, spreading material evenly over area to be covered.

B. Touch-up Painting: Immediately after erection, clean field welds, bolted connections, and braded areas of shop paint, and paint exposed areas with same material as used for shop painting. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

END OF SECTION 05500
SECTION 06100 – ROUGH CARPENTRY

1.1 SECTION 06100 – ROUGH CARPENTRY

A. Provide framing with dimensional lumber, rooftop equipment bases and support curbs, wood furring, grounds, nailers, blocking, fasteners, metal framing anchors and sheathing. See structural drawings for additional information.

END OF SECTION 06100
SECTION 06112 - WOOD FRAMING AND SHEATHING

PART I - GENERAL

1.1 SECTION INCLUDES

A. Rough carpentry for the following structural purposes:
   1. Framing with lumber for floors, walls and roofs.
   2. Sheathing with plywood or other wood panel products.

B. Rough carpentry for non-load bearing wood stud partitions and ceiling joists.

C. Expose wood framing at trellis and similar landscape structures.

D. Related framing anchors and connectors.

1.2 RELATED SECTIONS

A. Section 01450 - Quality Control: Wood tests and inspections.

B. Section 03100 - Concrete Formwork: Forming materials and formwork constructed of lumber and other wood products.

C. Section 03200 - Reinforcing Steel: Setting embedded anchors in concrete.

Section 05090 - Anchors and Fasteners: General requirements for anchors and fasteners to building substrates.

D. Section 05505 - Miscellaneous Metal Fabrications: Custom fabricated metal framing anchors.

E. Section 06114 - Wood Blocking, Backing and Curbing: Non-structural rough carpentry, including rooftop support curbs, wood grounds, nailers, blocking and furring.

F. Section 06200 - Finish Carpentry: Care and preparation for finishing of exposed wood structural members.

G. Section 07210 - Building Thermal Insulation: Requirements for wood framing to accommodate fiberglass batt insulation.

H. Section 09905 - Field Painting: Finish on exposed wood structural members.

1.3 DEFINITIONS

A. Rough Carpentry: Defined to include carpentry Work not specified as part of other Sections and generally not exposed, unless otherwise specified.

B. Timber: Defined to include structural framing of wood members with thicknesses of 5-inches (nominal or more)
1.4 REFERENCES

A. American Forest and Paper Association (AFPA; formerly National Forest Products Association):
   1. AFPA WCD #1 - Manual for Wood Frame Construction (National Design Specification for Wood Construction (NDS)).

B. American Plywood Association (APA):

C. American Wood Preservers Bureau (AWPB):
   1. AWPA C20 -- Structural Lumber Fire Retardant Treatment by Pressure Process.

D. NBS PS 1 - Construction and Industrial Plywood.

E. West Coast Lumber Inspection Bureau (WCLIB): WCLIB Standard Grading and Dressing Rules.

F. Western Wood Products Association (WWPA): WWPA Western Lumber Grading Rules.

1.5 SUBMITTALS

A. Engineered wood products.

1.6 QUALITY ASSURANCE

A. Inspection Agencies: Inspection agencies and the abbreviations used to reference them with lumber grades and species include the following:
   1. WCLIB - West Coast Lumber Inspection Bureau.
   2. WWPA - Western Wood Products Association.

B. Industry Standards:
   1. Lumber Grading Agency: Certified by WCLIB or WWPA as pertinent to product.
      a. Do not apply inspection service grade mark on timber shown as exposed in the work and with transparent finish.
      b. Submit certificate of grade compliance, obtained from grading agency with each shipment.
   2. Plywood Grading Agency: Certified by APA.

C. Regulatory Requirements: Conform to California Building Code (CBC) Chapter 23A for member and fastener sizes and type of fasteners, unless otherwise indicated on Drawings.

D. Single-Source Responsibility for Engineered Wood Products: Obtain each type of engineered wood products from one source from a single manufacturer.

1.7 DELIVERY, STORAGE AND HANDLING

A. Lumber Delivery and Storage: Keep materials under cover and dry. Protect against exposure to weather and contact with damp or wet surfaces.
   1. Stack lumber as well as plywood and other panels.
   2. Provide for air circulation within and around stacks and under temporary coverings including polyethylene and similar materials.
3. Heavy Timber Members: Time delivery and installation of timber work to avoid extended on-site storage.

PART 2 - PRODUCTS

2.1 DIMENSIONED LUMBER

A. Dimensioned Lumber: Provide lumber manufactured in compliance with PS 20 - American Softwood Lumber. Standards and with applicable grading rules of inspection agencies certified by American Lumber Standards Committee’s (ALSC) Board of Review.

B. Lumber Species and Grades: Wood species and stress grades as noted on the (Structural) Drawings. Regrade large members when cut or ripped.

C. Lumber Markings:
   1. Provide lumber with each piece factory-marked with grade stamp of inspection agency, evidencing compliance with grading rule requirements and identifying grading agency, grade, species, moisture content at time of surfacing, and mill.
   2. For exposed lumber furnish pieces with grade stamps applied to ends or back of each piece; or omit grade stamps entirely and provide certificates of grade compliance issued by inspection agency.

D. Lumber Sizes: Nominal sizes are indicated, except as shown by detail dimensions. Provide actual sizes as required by PS 20, for moisture content specified for each use.

E. Lumber for Load-Bearing Members: Species and grade as indicated on Structural Drawings, conforming to WCLIB or WWPA grading standards as applicable.

F. Surfacing: Provide dressed lumber, S4S, unless otherwise indicated.

G. Moisture Content: All lumber shall be kiln-dried to percent specified below. Air season in place, protected from rain and high humidity conditions, no less than 15 days before applying finish materials.
   1. Concealed lumber: 19 percent maximum moisture content at time of dressing and shipment, unless otherwise indicated.
   2. Exposed lumber and timber: 15 percent at time of delivery, unless otherwise indicated.

H. Exposed Framing: Provide material complying with the following requirements:
   1. By other construction and is indicated to receive a stained or natural finish.
   2. Grading: Material hand-selected at factory from lumber of species and grade indicated below that complies with Appearance grade requirements of ALSC National Grading Rule; issue inspection certificate of inspection agency for selected material.
   3. Species: Provide same species and grade as indicated for structural framing.

I. Non-load Bearing and Furring: Douglas fir, No.1 and Better grade, unless otherwise indicated on Drawings.

J. Miscellaneous Framing: For site structures and other exposed conditions, provide No. 1 grade Douglas fir-larch or better, selected for appearance. At site structures, provide light sandblast finish on exposed wood framing.
K. Wane: Limit wane to 5 percent of members in accordance with WWPA standards. Do not locate members with wane at plywood sheathing: joints, at solid blocking or at double plates.

2.2 STRUCTURAL PANELS

A. Plywood Materials, General: APA Performance-Rated Panels, Group 1 Series, PS 1, species and thickness as indicated on Drawings and as specified herein.

B. Plywood Panels for Roof Sheathing: Douglas fir, Structural I, APA RATED SHEATHING
   1. Exposure Durability Classification: EXTERIOR.
   2. Thickness: As indicated on the Drawings.
   3. Edge detail, low slope roofs: Square if all edges supported on framing or tongue-and-groove (T&G) if edges are unsupported. Ply clips will not be acceptable.

C. Plywood for Floor Sheathing: Douglas fir, Stud-I-Floor, APA RATED SHEATHING.
   1. Exposure Durability Classification: EXTERIOR.
   2. Thickness: As indicated on the Drawings. Thickness of plywood indicated on Drawings is minimum thickness.
   3. Edge detail: Provide either tongue and groove (T&G) plywood edges or square edges with full support of edges on framing and blocking. Plyclips will not be acceptable.

D. Plywood Panels for Wall Sheathing: Douglas fir, Structural I, APA RATED SHEATHING.
   1. Exposure Durability Classification: EXTERIOR.
   2. Thickness: As indicated on the Drawings.
   3. Edge detail: Square.

2.3 2.3 PRESERVATIVE TREATED WOOD PRODUCTS

A. Wood Treatments, General: Where used for exposed locations, treatment materials shall be types guaranteed to not adversely affect durability and appearance of applied finishes.
   1. Treatment materials having a highly persistent, noticeable residual odor will not be permitted.
   2. After treatment, kiln or air dry lumber and plywood to a moisture content of 19 percent or less.

B. Preservative Treatment, Members Intended for Finishing: Water-borne salt preservatives for painted, stained, or exposed natural wood product, AWPB LP-2, above ground application and AWPB LP-22, ground contact application.

C. Preservative Treatment, Members Not Intended for Finishing: Oil-borne preservatives for any construction except when in contact with salt water, AWPB LP-33, ground contact application, light petroleum solvent.

2.4 CONNECTORS

A. Framing Connectors:
   1. Specified Manufacturer: Simpson Strong-Tie Co., Pleasanton, CA (510/460-9912 or 800/9995099; local representatives, Brea, CA (714/871-8373 or 800/999-5099).
   2. Acceptable Manufacturers: None identified. Equivalent products of other manufacturers will be considered in accordance with the substitution provision specified in Section 01600 – Product Requirements. Substitutions shall have equivalent values according to current ICBO Research
Report and shall be used only with prior approval of. Architect, based on review by Structural Engineer, and shall be approved by Division of the State Architect (DSA).

3. Light framing connectors: Simpson Strong-Tie Connectors, formed of sheet steel, catalog numbers as indicated on the Drawings or, if not indicated, to suit Project conditions and approved by Architect and Division of the State Architect (DSA).

4. Heavy framing connectors: Simpson Strong-Tie Connectors, formed of steel plate or heavy gauge steel sheet, catalog number as indicated on the Drawings and to suit Project conditions. Provide custom or special-order framing connectors as indicated on the Drawings or, if not indicated, as necessary to suit Project conditions and approved by Architect and Division of the State Architect (DSA).

a. Stock framing connectors: Simpson - Strong Tie Connectors, catalog numbers as indicated on the Drawings or, if not indicated, to suit Project conditions as approved by Custom framing connectors and connectors for decorative purposes: Fabricated as indicated on Drawings and as specified in Section 05505 - Miscellaneous Metal Fabrications.

5. Finishes
   a. Light framing connectors: Provide manufacturer's standard galvanized finish.
   b. Heavy framing connectors, exterior: Hot-dipped galvanized, equivalent to ASTM A525, Coating Designation G90.
   c. Heavy framing connectors, interior: Plain steel with shop primer paint finish, as specified in Section 05505 - Miscellaneous Metal Fabrications.
   d. Custom framing connectors: Fabricated as specified in Section 05505 – Miscellaneous Metal Fabrications. At interior and concealed locations, provide plain steel with shop primer paint finish. At exterior locations, provide hot-dipped galvanized finish.

2.5 FASTENERS AND ANCHORS

A. By California Building Code (CBC). Comply with following requirements for materials and manufacturer.
   1. Provide electro-galvanized finish 'on fasteners at interior high humidity locations and exterior locations not directly exposed to weather.
   2. Provide hot-dipped galvanized finish on fasteners at exterior locations directly exposed to weather
   3. Plain finish fasteners may be provided elsewhere.

B. Anchor Bolts: ASTM A307 or as indicated on Drawings, galvanized steel at exterior locations.
   1. Do not upset threads on bolts.
   2. Provide headed anchor bolts for hold-downs.

C. Machine Bolts: ASTM A307, hex head and nut, full bearing on unthreaded shank, length for maximum 1-1/2 inch beyond nut, with steel washer under head and nut. Provide hot-dipped galvanized finish at exterior locations.

D. Code (CBC) Chapter 23A, Table No. 23A-II-B-I and applicable reference standard.
   1. No box nails shall be used.
   2. Machine applied nailing shall be subject to approval as specified on the Drawings and as approved by Division of The State Architect (DSA).

E. Roofing Nails: Size as noted on (Structural) Drawings, common wire nails at gable and hip roofs

F. Expansion Anchors: As specified in Section 05090 - Anchors and Fasteners.

G. Powder-Actuated Driven Fasteners: Provide powder-acted driven fasteners only if approved by
1. Architect (Structural Engineer). Generally, powder-driven fasteners will not be permitted at load bearing conditions. See Section 05090 - Anchors and Fasteners for fasteners. If permitted, provide fasteners of type and size as indicated and as recommended by manufacturer for Project conditions.


I. Grout for Sill Plates: Type S mortar cement grout in accordance with California Building Code (CBC) Table 21A-A.

J. Lag Bolts and Screws: Fed Spec FF-S-588, size as indicated on Drawings and as specified in Section 05090 - Anchors and Fasteners. Provide hot-dipped galvanized finish at exterior locations.


L. Cast Iron Washers and Spacers: Alhambra Foundry Co., Ltd Alhambra, CA (818/289-4294), black iron as shown on Drawings.

M. Bevel and Angle Washers: Alhambra Foundry Co., Ltd., Alhambra, CA (818/289-4294), as shown on Drawings.

N. Cast Iron Spool: Alhambra Foundry Co., Ltd., Alhambra, CA (818/289-4294), as shown on Drawings.

2.6 WOOD PRESERVATIVE TREATMENTS

A. Wood Preservative Treatments, General: Where lumber or plywood is indicated as preservative, treated or is specified to be treated, comply with applicable requirements of AWPA C2 (Lumber) and AWPA C9 (Plywood).
   1. Mark each treated item with the Quality Mark Requirements of an inspection agency approved by American Lumber Standards Committee (ALSC) Board of Review.
   2. Comply with California Building Code (CBC), Section 2303A.1.3, Section 2317A and Section 2326A.6.

B. Wood Members Located Above Ground: Pressure-treat above ground items with water-borne preservatives to a minimum retention of 0.25 pcf. After treatment, kiln dry lumber and plywood to a maximum moisture content of, respectively, 19 percent and 15 percent. Treat indicated items and the following:
   1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping and similar members related to roofing, flashing, vapor barriers and waterproofing.
   2. Wood sills, sleepers, blocking, furring, stripping and similar concealed members in contact with masonry or concrete.

C. Wood Members Located in Contact with Ground: Pressure-treat wood members in contact with ground or fresh water with water-borne preservatives to a minimum retention of 0040 pcf.

D. Coordination with Fabrication: Complete fabrication of treated items prior to treatment, where possible. If cut after treatment, coat cut surfaces in compliance with AWPA M4. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.
PART 3 - EXECUTION

3.1 PREPARATION

A. Coordination:
1. Coordinate placement of framing connectors and supports with applied finishes to minimize bowing and cutouts.
2. Coordinate framing and sheathing with installation of glue laminated structural units and other engineered wood framing members, ducts and conduits to avoid penetrations through load bearing framing.
3. Coordinate framing with plumbing, mechanical and electrical Work to provide means to support components and equipment and to provide suitable openings through framing.
4. Request direction from Architect for all openings through stud, rafter and joist framing exceeding 24-inches in any direction if opening framing are not detailed on Drawings.

3.2 WOOD FRAMING

A. Wood Framing Members: Provide framing members sized as indicated on Drawings or, if not indicated, in accordance with California Building Code (CBC), Chapter 23A.

B. Wood Framing Erection: Erect wood framing members level and plumb, or to indicated slope. Place horizontal members flat, with crown side-up. Construct framing members full splices, except as noted.

C. Sill and Head Plates, Typical:
1. Provide single bottom plate and double top plates, nominal 2-inches thick by width of studs. Provide nominal 3-inch bottom plates where indicated on Drawings.
2. Overlap double plates minimum of 4 feet or as indicated on Drawings and at corners and intersections. Face nail upper plate to lower top plate as indicated on Drawings.
3. Provide nominal 3-inch bottom plates where indicated on Drawings. Nail bottom plate to wood framing with indicated sill nailing. Anchor bottom plate to concrete structure with anchor bolts. Expansion bolts will not be permitted at load-bearing conditions.
4. Install pressure preservative treated lumber for sill plates in accordance with California Building Code (CBC) Section 2303A.
   a. Bolt sills to foundations and slabs. Level sills with shims, washers placed, and nuts tightened to level bearing.
   b. Pack space between sill and concrete with dry-pack cement grout mixed at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with only enough water for placement and hydration.

D. Studs:
1. Toenail studs to bottom plate and end nail to lower top plate.
2. Provide triple studs at corners and partition intersections.
3. Provide additional studs at corners and intersections as necessary to secure sheathing, Gypsum board and other applied components.
4. Anchor studs abutting concrete and masonry with S/8-inch diameter anchor bolts, with minimum 8-inches embedment unless otherwise indicated, spaced maximum 48-inches on center or as indicated on Drawings.

E. Posts and Columns:
1. Align surfaces on posts flush with wall surface for installation of interior finish materials.
2. At built-up posts, arrange and nailed together as indicated and in accordance with Code requirements for construction type.
3. Erect posts straight and plumb.

F. Beams and Girders:
1. Install beams and girders with crown edges up.
2. Frame as indicated on Drawings.
3. Provide solid bearing at ends of each member.
4. Nail built-up beams and girders with two rows of 20d nails spaced maximum of 16-inches on center locating one row near top edge and other near bottom edge of member.

G. Joists from Lumber:
1. Install joists with crown edges up.
2. Support ends of each member minimum 1-1/2 inches of bearing on wood.
3. Provide double joist headers at floor, ceiling and roof openings. Provide double joists under wall and parapet studding and under curbs.
4. Fit solid blocking at ends of members.

H. Openings and Recesses:
1. Provide double or triple studs and headers at all openings and recesses.
2. Double members at openings over 18-inches in width or height.
3. Space short studs over and under opening to maintain stud spacing continuity.

I. Headers
1. Provide continuous headers, same width as studs and of depth required to span widest opening.
2. Toenail headers to studs and opening framing or provide hangers.
3. Lap headers at intersections with bearing partitions or tie with metal straps.
4. Frame rigidly into joists.

J. Stud Blocking:
1. Install blocking in continuous horizontal row at mid-height of unsheathed single story partitions over 8 feet high and in all multi-story partitions, for structural rigidity.
2. Coordinate blocking with anchoring provisions for products attached to walls, as specified in other Sections.

K. Joist and Rafter Blocking
1. Block joist and rafter ends with solid blocking, nominally 2-inches thick by depth of member.
2. Also block joists and rafters at all locations where members cross bearing points.

L. Joist and Rafter Bridging:
1. Where nominal depth-to-thickness ratio of joists exceeds 8-inches and span exceeds 10-feet, install solid bridging.
2. Provide bridging of nominal 2-inch width by joist or rafter depth.
3. Install blocking offset to permit 'toe-nailing or end-nailing.
4. Bridging shall comply with the following, unless otherwise indicated on Drawings.

<table>
<thead>
<tr>
<th>Span</th>
<th>Bridging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spans to 10 feet</td>
<td>None required, except as noted above</td>
</tr>
<tr>
<td>Spans 10 feet to 20 feet</td>
<td>One row at midspan</td>
</tr>
<tr>
<td>Spans over 20 feet</td>
<td>Rows evenly spaced, not exceeding 8 feet on center</td>
</tr>
</tbody>
</table>
M. Fire Blocking: Fire block wood framing with wood blocking accurately fitted to close spaces, at concealed spaces in walls at each floor level, at ceiling line of top story, every 10 feet vertically and at other locations in compliance with California Building Code (CBC), Section 708.2.

N. Fastening, General: Drill holes for fasteners and size as noted.
   1. Nails and spikes: Smaller than diameter of fastener. Pre-drill as necessary to prevent splitting.
   2. Lag bolts: Drill holes same diameter and length as shank. Bit size shall be no larger than base of threaded portion of bolt.
   3. Bolts: Holes shall be 1/32- to 1/16-inch larger than bolt.
   4. Powder-actuated driven fasteners: Do not install on curbs or at edge of slab closer than as noted in applicable ICBO Evaluation Service, Inc., Evaluation Report.

O. Nailing: As indicated on the Drawings. If not indicated, conform to California Building Code (CBC), Chapter 23A, Table No. 23A-II-B-1, unless otherwise directed.
   1. Spacing: 1/2 length of nail minimum.
   2. Edge distance: 1/4 length of fastener.
   3. Toe nailing: Drive toe nails at angle or approximately thirty degrees with the piece and started approximately one-third the length of the nail from end of piece.
   4. Replace split or otherwise damaged structural members.

P. Framing Connectors: Drive nails into all holes of each connector. Install bolts in each framing connector unless detailed otherwise. Where hole is smaller than diameter of fastener, predrill as required to prevent splitting.

Q. Bolts: Use standard cut washer under bolt heads and nuts against wood. Use heavy plate washer or malleable iron washer where noted on Drawings. Drive into place. Ensure full engagement of nut, but projection of bolt beyond nut not to exceed one bolt diameter. Tighten nuts at installation and again immediately prior to enclosure.

R. Lag Bolts: Lubricate with soap or similar material. Turn into place without driving. Ensure penetration into lagged member of 60 percent of bolt length. Lead hole shall have diameter of about 70 percent of the roof diameter of the bolt. Provide washers of same size as specified for bolts.

S. Expansion Anchor Bolts: Install anchors in snug fitting, smoothly drilled holes, in accordance with the manufacturer's written instructions. Install expansion bolts so that load acts on bolts in shear rather than withdrawal.

T. Hold-Down Anchors:
   1. Provide minimum of 1-inch vertical clearance at bottom of all anchors from sill plate.
   2. All bolts in post for hold-down installation shall have plate washers installed beneath nuts and bolt heads.

U. Bolt Retightening: Retighten all bolts prior to closing-in walls.

3.3 CONSTRUCTION PANELS INSTALLATION

B. Draftstops: Provide draftstops at attic spaces in conformance to California Building Code (CBC), Chapter 23A and as indicated on the Drawings. Use plywood or gypsum board, as permitted by California Building Code (CBC). See Section. 09250 - Gypsum Board for gypsum board.

C. Fastening Methods: Nail or screw panels to supports. Additionally, use construction adhesive where construction panels will serve as wall paneling or true panel surface is required.

D. Sheathing Installation, General:
1. Stagger end joints to avoid four-corner intersections.
2. Allow minimum 1/8-inch space between end joints and 1/8-inch at edge joints for expansion and contraction of panels, typically.
3. At OSB, allow 1/2-inch gap between concrete or, masonry and OSB panel.
4. Provide panels not less than 8 square feet in area and with no dimension less than 24-inches, in compliance with California Building Code (CBC) Section 2315A.3.3.

E. Floor Sheathing:
1. Provide panel thickness and index as indicated on Drawings.
2. Install floor sheathing with long dimension parallel to framing, with end joints occurring over framing or lumber blocking only. Fully support panel, cut edges and all ends with blocking. Plyclips will not be accepted.
3. Install floor sheathing with long dimension perpendicular to framing, with panel end joints occurring over framing or lumber blocking only. Use T&G plywood and fully support cut panel edges with lumber blocking. Plyclips will not be acceptable.
4. Apply bead of construction floor adhesive to top of framing members before placing and nailing plywood. Provide adhesive at all floor sheathing.

F. Roof Sheathing
1. Provide panel thickness and index as indicated on Drawings.
2. At flat (low slope) roofs, either install square edge plywood roof sheathing with long dimension parallel to framing, with end joints occurring over framing or lumber blocking only.Fully support panel, cut edges and all ends with blocking. Plyclips will not be accepted.
3. Provide wood filler strips on top of framing anchors and other elements which require cut-outs of plywood, to create level surface on which roofing and underlayment may be applied.

G. Wall Sheathing:
1. Provide panel thickness as indicated on Drawings.
2. For lateral bracing walls, install wall sheathing as noted on Drawings.
3. For plywood sheathing used as backing support and not lateral bracing, install wall sheathing with long edge parallel to framing members. End joints do not require blocking.

H. Sheathing Nailing: Conform to California Building Code (CBC), Chapter 23A, Section 2315A.3.3 and Table No. 23A-II-H and 23A-11-1-1, unless otherwise indicated on Drawings.
1. Use of machine nailing shall be subject to a satisfactory Work site demonstration for this Project and shall be subject to approval by Architect (Structural Engineer) and the Division of the State Architect (DSA). Approval shall be subject to continued satisfactory performance.
2. Machine nailing will not be approved for plywood 5/16-inch thick and less.
3. If nailheads penetrate the outer ply more than would be normal for hand hammer or if minimum allowable edge distances are not maintained, machine nailing will be determined to be unsatisfactory and machine nailing shall be discontinued.
3.4 TREATED WOOD

A. Treated Wood, General: Provide pressure preservative treated lumber and plywood at all locations where wood members have contact with concrete or grout.

B. Type A Treatment (Surface Applied Preservative): Apply to pretreated lumber and plywood members after cutting, shaping, and bolting.
   1. Apply Type A preservative treatment in accordance with manufacturer's instructions.
   2. Air-dry members before setting into place.

C. Type B Treatment (Pressure Treated Preservative): After cutting, shaping, and boring, retreat surfaces using materials and methods in complying with instructions of pressure-treatment manufacturer.

3.5 TOLERANCES

A. Framing Members: 1/4-inch maximum from true position.

B. Surface Trueness of Roof Decks and Floors: 1/4-inch in 10 feet maximum.

3.6 PROTECTION

A. Protection of Exposed Members: Provide temporary covers as necessary to prevent soiling, staining and marring. Schedule and coordinate installation of permanent weather barriers to minimize exposure of framing and sheathing to inclement weather.

B. Protection of Exposed Interior Members: For interior timber construction, maintain lair temperature and humidity conditions in building to facilitate in-place drying of lumber and to avoid damage or deterioration of wood framing and sheathing.

END OF SECTION 06112
SECTION 06114 - WOOD BACKING, BLOCKING AND CURBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Blocking for wall and roof openings.
B. Roof curbs.
C. Wood furring and grounds.
D. Construction panels for non-structural deck and wall sheathing and backing.
E. Related framing anchors and connectors.

1.2 RELATED SECTIONS

A. Section 03100 - Concrete Formwork: Requirements for embedded nailers and grounds.
B. Section 06112 - Wood Framing and Sheathing: Structural (load bearing) wood framing and sheathing.
C. Section 06200 - Finish Carpentry: Construction panels for backboards at electrical, telephone and other communications equipment and terminals.
D. Section 07514 - Mechanically Attached Thermoplastic Membrane: Requirements for wood cants and backing for roofing.
E. Section 09220 - Portland Cement Plaster: Framing requirements for attachment of gypsum base panels.
F. Section 09250 - Gypsum Board: Framing requirements for attachment of gypsum board.

1.3 REFERENCES

A. American Plywood Association (APA):
   1. APA Form E30L -- Residential & Commercial.


C. U.S. Department of Commerce, National Bureau of Standards:
   1. NBS PS 1 - Construction and Industrial Plywood.

D. West Coast Lumber Inspection Bureau (WCLIB): Standard Grading and Dressing Rules No. 17.

E. Western Wood Products Association (WWPA): WWPA Western Lumber Grading Rules.
1.4 QUALITY ASSURANCE.

A. Industry Standards:
   1. Lumber Grading Agency: Certified by WCLIB or as pertinent to product.
      a. Do not apply inspection service grade mark on timber shown as exposed in the work and with transparent finish.
      b. Submit certificate of grade compliance, obtained from grading agency with each shipment
   2. Plywood Grading Agency: Certified by APA.

B. Regulatory Requirements: Conform to California Building Code (CBC), Chapter 23A, for member and fastener sizes and type of fasteners, unless otherwise indicated on Drawings.

C. Coordination: Coordinate provision of wood blocking and backing for products installed to wall and ceilings. All applied products require fastening to solid wood blocking and backing. Toggle bolts or other hollow wall fasteners will not be permitted except where specifically noted.

1.5 DELIVERY, STORAGE AND HANDLING

A. Lumber Delivery and Storage: Keep materials under cover and dry. Protect against exposure to weather and contact with damp or wet surfaces.
   1. Stack lumber as well as plywood and other panels
   2. Provide for air circulation within and around stacks and under temporary coverings including polyethylene and similar materials.

PART 2 - PRODUCTS

2.1 DIMENSION LUMBER AND BOARDS

A. Dimension Lumber and Boards, General: Provide Douglas fir or Douglas fir/larch, grade as appropriate for intended use. Blocking stock shall be solid and without defects detrimental for use to secure attached

B. Lumber Standards: Furnish lumber manufactured to comply with PS 20 - American Softwood Lumber Standard, and with applicable WCLIB Grading Rules or WWPA Grading Rules
   1. Provide lumber with each piece factory-Marked with grade stamp of inspection agency evidencing compliance with grading rule requirements and identifying grading agency, grade, species, moisture content at time of surfacing, and mill.
   2. Inspection agencies and the abbreviations used to reference them with lumber grades and species include the following:
      a. WCLIB - West Coast Lumber Inspection Bureau.
      b. WWPA - Western Wood Products Association. 

C. Lumber Sizes: Nominal sizes are indicated, except as shown by detail dimensions. Provide actual sizes as required by PS 20, for moisture content specified for each use.

D. Surfacing: Provide dressed lumber, S4S, unless otherwise indicated.

E. Moisture Content: All lumber shall be kiln-dried to percent specified below. Air season in place, protected from rain and high humidity conditions, no less than 15 days before applying finish materials.
   1. Concealed lumber: 19 percent maximum moisture content at time of dressing and shipment, unless otherwise indicated.
   2. Exposed lumber and timber: 15 percent at time of delivery, unless otherwise indicated.
3. Wane: Limited to a minimum of 5 percent of members in accordance with WWPA rules. Do not locate members with wane at plywood sheathed joints, at solid blocking, or at double plates.

2.2 CONSTRUCTION PANELS

A. Construction Panels, General: APA Performance-Rated Panels, species and thickness as indicated on Drawings and as specified herein.
   1. Comply with PS 1-95 Series for plywood (cross-laminated wood veneer) panels.
   2. Comply with PS 2-92 for composite (veneer faces bonded to wood strand core) and oriented strand board (OSB) panels.

B. Roof Crickets and Curbs: Provide construction panels for roof crickets and sheathing at curbs.
   1. Provide panel thickness and span rating to suit framing spacing but not less than 1/2-inch thick
   2. Coordinate thickness with requirements for roofing fire and wind uplift ratings.

2.3 CONNECTORS AND ANCHORS

A. Framing Connectors: As indicated on Drawings, formed of galvanized sheet steel. Provide configurations as indicated and to suit Project conditions.
   1. Specified Manufacturer: Simpson Strong-Tie Co., Pleasanton, CA (510/460-9912 or 800/9995099; local representatives, Brea, CA, 714/871-8373).
   2. Acceptable Manufacturers: None identified. Equivalent products of other manufacturers listed below will be considered in accordance with the substitution provision specified in Section 01600 - Product Requirements.
   3. Light framing connectors: Simpson Strong-Tie Connectors, formed of sheet steel, catalog number as indicated on the Drawings and to suit Project conditions.

B. Fasteners, General: Size and type as required by California Building Code (CBC) requirements and as indicated on Drawings. Comply with general requirements for anchors in Section 05090 - Anchors and Fasteners.
   1. Provide electro-galvanized finish at interior high humidity locations and exterior locations not directly exposed to weather.
   2. Provide hot-dipped galvanized at exterior locations directly exposed to weather.
   3. Plain finish may be provided elsewhere.

C. Anchor Bolts: ASTM A 307 or as indicated on Drawings, galvanized steel at exterior locations.

D. Machine Bolts: ASTM A 307, hex head and nut, full bearing on unthreaded shank, length for maximum 1-1/2 inch beyond nut, with steel washer under head and nut.

E. Nails, Typical: Types and sizes as indicated on Drawings and as required by California Building Code (CBC), Chapter 23A, Tables 23-11-B-1 and 23-11-B-2.

F. Roofing Nails: Common wire nails at gable and hip roofs and ring shank plywood nails at flat roofs, sizes as noted on (Structural) Drawings and in compliance with minimum requirements of California Building Code (CBC) Table

G. Lag Bolts and Screws: Fed Spec FF-S-588, size as indicated on

I. Expansion Anchors: As specified in Section 05090 – Anchors and Fasteners.

J. Power-Actuated Driven Fasteners: As specified in Section 05090 - Anchors and Fasteners. Use only if approved by Architect, generally not permitted where not specifically indicated or in load-bearing installations.


2.4 WOOD TREATMENTS

A. Wood Treatments, General: Where used for exposed locations, treatment materials shall be types guaranteed to not adversely affect durability and appearance of applied finishes.
   1. Treatment materials having a highly persistent, noticeable residual odor will not be permitted.
   2. After treatment, kiln or air dry lumber and plywood to a moisture content of 19 percent or less.
   3. Type A (Surface Applied Preservative): Apply to pretreated lumber and plywood members after cutting, shaping, and boring.
   4. Type B (Pressure Treated Preservative): Provide pressure preservative treated lumber and plywood at all locations where wood members have contact with concrete, masonry or grout.

B. Surface-Applied Wood Preservative (Type A): For field application.
   1. Non-aqueous solution containing not less than five percent pentachlorophenol, commercially prepared and formulated to repel water and inhibit decay.
   2. Suitable for application by either brush or dip methods.
   3. Integral coloring to allow visual inspection of treated members.

C. Pressure-Treated Wood Preservative (Type B): For factory application.
   1. Required for lumber and plywood where indicated or specified and not otherwise required to be fire-retardant pressure treated.
   2. Concealed Locations: Any process acceptable in meeting accordance with UBC Standard 25-12 and specified requirements.
   3. Exposed Locations: Treated members shall be milled smooth within limits permitted by process manufacturer.

PART 3 - EXECUTION

3.1 CARPENTRY, GENERAL

A. Carpentry, General: Conform to details indicated on the Drawings. If details are not indicated, conform to California Building Code (CBC) requirements and to AFPA VVCD #1 - Manual for Wood Frame Construction.
   1. Cut pieces for full wood-to-wood fit at connections. Do not splice free standing members except where lengths are not available to span distance. If splicing or interrupting of members is needed, engineer joint to provide same strength as whole member times a suitable safety factor.
   2. Examine each piece of lumber before setting in place. Put the most sound pieces in positions of greatest stress. Select clearest pieces for exposed use. Discard pieces which have defects that impair their structural function.
   3. Set members plumb, level, or to slope shown. Set members bark side up.
   4. Do not cope or notch horizontal members more than 1.16 their depth in center third of span, nor more than 1/4 joist depth at end thirds. Drill joists for passage of lines in end thirds only. Drilled holes shall be no more than 1/3 joist depth, and shall leave a full 2-inches of wood top or bottom.
5. Do not cut or notch studs in bearing or exterior walls more than 1/4 stud width. Do not drill holes more than 2/5 of the width of these studs; leave at least 3/4-inch of wood each side. In non-bearing walls studs may be cut 2/5 of their width and holes may be 3/5 of stud width.

6. Cut and fit carpentry work accurately to make tight fits without gaps. Allow for expansion at roof plywood sheathing.

B. Cutting and Drilling for Work specified in other Sections: Make penetrations in accordance with Building Code and as indicated on Structural Drawings. Notching will not be permitted except as shown or specified herein.

3.2 FRAMING

A. Wood Framing Members: Provide framing members sized as indicated on Drawings or, if not indicated, in accordance with California Building Code (CBC), Chapter 23A.

B. Wood Framing Erection: Erect wood framing members level and plumb, or to indicated slope. Place horizontal members laid flat, crown side-up. Construct framing members full length without splices.

C. Roof Sheathing Blocking: Provide solid blocking at panel edges where tongue and groove plywood is not provided.

3.3 TREATED LUMBER

A. Preservative Treated Lumber: Provide pressure preservative treated (PPT) lumber at the following

1. Wood in contact with slabs on grade and foundation walls, such as sills, sleepers, furring and posts.
2. Wood buried in or in contact with soil.
3. Wood in exterior framed structures.
4. Wood in exterior accessory structures.
5. Wood above structural roof deck, such as roof blocking, sleepers, nailers, roof curbs, equipment supports and roof cants.
6. Wood in moist locations, such as trenches, tunnels, sumps and washing areas.
7. Provide pressure preservative-treated lumber at other locations indicated on Drawings.

B. Treated Lumber Installation: Install PPT lumber with galvanized steel or stainless steel fasteners and connectors that do not react with the particular treatment salt that has been used.

C. Touch-Up: Apply a heavily brushed touch-up coat to cuts, holes and abraded or dented areas of each piece of treated lumber using specified chemical.

3.4 BLOCKING AND OTHER SUPPORT MEMBERS

A. Blocking and Miscellaneous Framing: Select sound lumber for blocking, nailers, sleepers, cants, curbs, equipment support bases, blocking, stripping and similar members related to roofing, flashing, and vapor barriers.

1. Wood sills, sleepers, blocking, furring, stripping and similar concealed members in contact with masonry or concrete.
2. Wood floor plates installed over concrete slabs directly in contact with ground.

B. Wood Members Located in Contact with Ground: Pressure-treat wood members in contact with ground or fresh water with water-borne preservatives to a minimum retention of 0040 pcf.
C. Coordination with Fabrication: Complete fabrication of treated items prior to treatment, where possible. If cut after treatment, coat cut surfaces in compliance with AWPA M4. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

D. Nailing: As indicated on the Drawings and in conformance to California Building Code (CBC), Chapter 23A, Table No. 23-1-Q.

E. Bolt Holes: Oversize holes in members, 1/16-inch typically. At sill plates, locate as indicated on Structural Drawings.


G. Wall and Roof Openings: Prepare openings and frame for all recessed products, ductwork and equipment. Provide minimum 12-inch high curb (measured at high point) at all roof openings except where prefabricated curbs are provided. Form curb corners by lapping side members alternately. Face all curbs with 1/2-inch plywood or provide face of solid wood framing.

H. Roof Cricket Framing: Provide 2x framing ripped to required slopes of main roof and cricket. Space cricket framing 24-inches on center maximum and at all edges of cricket panels.

3.5 WOOD NAILERS, BLOCKING, AND SLEEPERS INSTALLATION

A. Wood Nailers, Blocking and Sleepers:
   1. Install wood nailers, blocking, and sleepers where shown and where required for screeding or attachment of other Work.
   2. Form wood members and assemblies to shapes as shown and cut as required for true line and level of work to be attached.

B. Attachment: Attach nailers, blocking and sleepers to substrates as required to support applied loading.
   1. Countersink bolts and nuts flush with surfaces, unless otherwise indicated.
   2. Where possible, anchor nailers to formwork before concrete placement.

3.6 WOOD FURRING INSTALLATION

A. Wood Furring: Provide where indicated. Install furring plumb and level, with closure strips at edges and openings. Shim with wood as required for tolerance of finished Work.

3.7 FURRING AND GROUNDS

A. Furring: Provide PPT furring at exterior walls and in damp locations.

B. Furring Details: Terminate vertical furring with horizontal firestop strip at floor, opening and ceiling lines. Position to provide fastening for edges of wall finish material and base and cove trim.

C. Grounds: Execute furring at openings to serve as grounds for finish Work. Shim furring and grounds to make finish work plane and flush with opening frames. Bevel plaster grounds to form

D. Furring Options: The choice of using wood or metal furring in each area is Contractor's option, except behind plywood paneling, where wood shall be used. Select furring type that will receive finish fasteners.
E. Furring Members: Do not use furring strips with knots or missing knots where nail or screw fastening of plywood finish will be employed. Construct framing members full length without splices, except as indicated.

F. Furring to Receive Plywood Paneling and Backboards: Provide 1x3 or 1x2 furring spaced 16-inches o.c. for all finishes, except that plywood paneling 3/8-inch or thicker may be fastened to 1x3 furring 24-inches o.c. Select furring for freedom from knots capable of producing bent-over nails and resulting damage to paneling.

G. Fasteners: Provide quality and size of fasteners that will support live and dead loads. Recess bolts and nuts as necessary to avoid conflict with roofing and other adjoining or covering work. Provide washers where bolt heads and nuts bear against.

3.8 CONSTRUCTION PANELS INSTALLATION


B. Draftstops: Provide draftstops at attic spaces in conformance to California Building Code (CBC), Chapter 23A and as indicated on the Drawings. Use plywood or gypsum board, as permitted by California Building Code (CBC). See Section 09250 - Gypsum Board for gypsum board.

C. Fastening Methods: Nail or screw panels to supports. Additionally, use construction adhesive where construction panels will serve as wall paneling or true panel surface is required.

D. Plywood Sheathing Installation, General:
   1. Apply plywood directly to wood members.
   2. Do not use unblocked plywood diaphragms for vertical diaphragms.
   3. Stagger end joints to avoid four-corner intersections:
   4. Allow minimum 1/16-inch space between end joints and 1/8-inch at edge joints for expansion and contraction of panels, typically

E. Construction Panels at Roof Crickets:
   1. Install square edge panels for crickets with long dimension parallel to framing and with end joints occurring over framing or lumber blocking only. Fully support panel cut edges and all ends with lumber blocking.
   2. Secure plywood with ring-shank nails.

F. Construction Panels at Curbs and Other Vertical Conditions: Secure panels as for general wall sheathing specified on Structural Drawings.

G. Sheathing Nailing: Conform to California Building Code (CBC), Chapter 23A, Tables No. 23A-II-H and 23A-II-1, unless otherwise indicated on Drawings.
   1. Use of machine nailing shall be subject to a satisfactory jobsite demonstration for each project and shall be subject to approval by Architect (Structural Engineer) and the Division of the State Architect. Approval shall be subject to continued satisfactory performance.
   2. Machine nailing will not be approved in 5/16-inch thick plywood.
   3. If nailheads penetrate the outer ply more than would be normal for hand hammer or if minimum allowable edge distances are not maintained, machine nailing will be deemed to be unsatisfactory.
3.9 TOLERANCES

A. Framing Members: 1/4-inch maximum from true position.

B. Surface Trueness of Roof Decks: 1/4-inch in 10 feet maximum.

3.10 PROTECTION

A. Protection of Exposed Members: Provide temporary covers as necessary to prevent soiling, staining and marring.

B. Protection of Exposed Interior Members: For interior timber construction, maintain air temperature and humidity conditions in building in order to avoid damage or deterioration of Work.

END OF SECTION 06114
SECTION 06174 – WOOD I-JOISTS

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Plant designed and manufactured I-section wood joists with plywood webs.
B. Related stiffeners and blocking shapes to suit wood I-joist profiles.
C. Related framing anchors and connectors.

1.2 RELATED SECTIONS
A. Section 06112 - Wood Framing and Sheathing: Surrounding wood frame structure construction.

1.3 QUALITY ASSURANCE
A. Regulatory Requirements: Conform to California Building Code (CBC), Chapter 23A.
B. Fabricator's Qualifications: In addition to conforming with all applicable Codes and regulations, manufacture wood I-joists in a plant approved for fabrication, by the Division of the State Architect (DSA).
C. Design Criteria: All joists shall be from one manufacturer.
1. Wood Hoists shall be sized and detailed to fit the dimensions and loads indicated on Drawings.
2. Designs shall be in accordance with allowable values and section properties assigned and approved by the Division of the State Architect (DSA). Section properties of the joist only (not to include sheathing) shall be used in deflection calculations.
3. Design of wood I-joists shall be verified upon request of Architect by submission of complete calculations.

1.4 DELIVERY, STORAGE AND HANDLING
A. Identification: Piece-mark and wrap wood I-joists in packages before arrival at jobsite.
B. Protection: Members shall be protected from weather and damage during transportation, erection, and construction.

1.5 SUBMITTALS
A. Submittals, General: For pre-fabricated wood I-joists, all submittals shall be submitted to and gain approval from Code authorities having jurisdiction, prior to submission to Architect for review. Refer to the Structural Drawings for design/build requirements and deferred submittals. Submittals shall contain
all information necessary for review and approval by Code authorities having jurisdiction and shall consist, at a minimum, of the following.

B. Shop Drawings: Show all critical dimensions for determining fit and placement in the building as well as loads the members are designed to support. Review of shop drawings shall be completed prior to fabrication. Drawings shall be prepared, stamped and sealed by Structural Engineer licensed in California.

C. Calculations' Submit structural calculations prepared and sealed by Structural Engineer licensed in California. Submit calculations with shop drawings, for inclusion with shop drawings for review by Code authorities having jurisdiction.

1.6 DELIVERY, STORAGE AND HANDLING

A. Storage: Store material at site off the ground in a vertical position.

B. Handling: Members shall be, protected from weather and damage during transportation,

1.7 PROJECT CONDITIONS

A. Coordination: Coordinate and fit wood I-joists with carpentry Work and other related Work. Scribe and cope as required for accurate fit. Locate joists and related furring, nailers, blocking, grounds and similar supports to allow proper attachment of other Work.

PART 2 - PRODUCTS

2.1 WOOD I-JOISTS

A. Acceptable Manufacturers: Products of the manufacturers listed below will be acceptable if in compliance with specified requirements. Products of other manufacturers will be considered in accordance with the substitution provision specified in Section 01600 - Product Requirements. Use of products other than those of the specified manufacturer, as indicated on the Drawings, shall meet or exceed the section modulus of elasticity and moment of inertia (EI) of the specified products, and shall be conditional based on approval by the Division of the State Architect (DSA). Depths of wood I-joists shall not exceed those of products indicated on the Drawings, unless approved by Architect. Costs of plan check and redesign to accommodate products other than those of the specified manufacturer, as indicated on the Drawings, shall be paid by Contractor.

3. Willamette Industries, Inc., Woodburn, OR, (503/981-6003)

B. Manufactured Wood Joists: Manufacturer, types and sizes as indicated on Drawings, complying with UBC Standard 25.1737 and ICC Evaluation Service, Inc. (ICC ES) Service Research Report or Evaluation Report, including conditions of acceptance by the Division of the State Architect (DSA). Acceptable products are:

2. SSI Joists, manufactured by Standard Structures, Inc. and complying with ICBO ES PFC-4325.
3. WSI Joists, manufactured by Willamette Industries, Inc. and complying with ICBO ES PFC4544 51 (Supplement No. 1.).

C. Fabrication: Shop, fabricate, all joists in accordance, with referenced standards and for use in accordance with applicable research report and conditions of acceptance by the Division of the State Architect (DSA).

D. Webs: Fabricated from structural panels complying with requirements for APA Performance-Rated Panels, for Structural I, APA RATED SHEATHING, Exposure 1, complying with PS 1-95 Series for plywood (cross-laminated wood veneer) panels.

E. Flanges: Grade as required by design computations and species as indicated on Drawings.

F. Adhesives: Waterproof types, as standard with joist manufacturer.

G. Framing Anchors and Fasteners: Comply with requirements specified in Section 06112 – Wood Framing and Sheathing, except provide framing anchors and fasteners as required and recommended by joist manufacturer, as applicable.

H. Accessory Web Joist. Members: Provide manufactured wood joist blocking elements and stiffeners by web joist manufacturer, as required for complete, braced framing system and fireblocks, complying with requirements of applicable ICC Evaluation Service, Inc. (ICC ES) Report and including conditions of acceptance by the Division of the State Architect (DSA).

1. Provide web stiffeners at all points of support.
2. Provide fireblocks as necessary for compliance with California Building Code (CBC) requirements.

2.2 WOOD I-JOIST FABRICATION

A. Wood I-Joist Fabrication: Shop fabricate all joists in accordance with referenced standards and for use in accordance with applicable ICC Evaluation Service, Inc. (ICC ES) Report and according to conditions of acceptance by the Division of the State Architect (DSA).

1. Fabricate wood I. joists in accordance with notes on Drawings.
2. Provide continuous chords without joints.
3. Install plywood sections with face grain vertical and butt jointed and glued to form continuous plywood web.
4. Pressure form web and fit into groove in center of wide face of flange members, to form a pressured glue joint at that juncture.
5. For spans greater than 20'40", manufacture wood I-joists with camber based on radius of 2250'0", unless otherwise indicated on the Drawings.

2.3 SOURCE QUALITY CONTROL

A. Provide continuous inspection of fabrication, by a compliance assurance or inspection agency listed in applicable ICC Evaluation Service, Inc. (ICC ES) Report, as part of manufacturer's standard in-plant inspection policies and procedures.

1. After fabrication and inspection, stamp each wood I-joist member with an identifying mark, noting name and plant number of manufacturer, grade, applicable ICC Evaluation Service, Inc. (ICC ES) Report, and identification of quality control agency.
PART 3 - EXECUTION

3.1 PREPARATION

A. Coordination and Sequencing: Coordinate and sequence wood I-joist installation and installation details with Work specified in other Sections.
   1. Ensure proper interface of joists with adjoining components, to minimize cutting and penetration of joists and to limit erected joists to the shortest possible exposure to the elements before closing-in of building envelope.
   2. Do not install joists until supporting construction is in place and is braced and secured.

3.2 ERECTION

A. Erection: Erect and secure wood I-joists as indicated on Drawings, the reviewed shop drawings and manufacturer's installation instructions and recommendations.
   1. Space, adjust and align joists in proper locations before permanently fastening. Align joists between supports and hold in place with temporary bracing until sheathing is secured in place.
   2. Immediately fasten joists to supporting construction after setting in proper location, with joists plumb, square true to line. Use fasteners as indicated on the Drawings and in accordance with applicable ICC Evaluation Service, Inc. (ICC ES) Report, including conditions of acceptance by the Division of the State Architect (DSA).
   3. Make connections and install all blocking, stiffeners and bridging as erection progresses and before construction loads are imposed on joists.
   4. Do not permit temporary construction loads which cause member stresses beyond design limits.

B. Construction Loads: Do not permit temporary construction loads which cause member stresses beyond design limits.

C. Blocking and Stiffeners: Install blocking and stiffeners as required and shown for lateral support of members, to provide nailing surface for sheathing and finish materials and to Fireblock cavities in accordance with code.

D. Erection Bracing: Provide erection bracing in, addition to specified bridging to keep joists straight and plumb and to assure adequate lateral support until sheathing material has been applied.

E. Blocking, Stiffeners and Bridging: Install blocking, stiffeners and bridging in accordance with manufacturer's instructions and recommendations and as required by ICC Evaluation Service, Inc. (ICC ES) Research Report, including conditions of acceptance by the Division of the State Architect (DSA), and shown on Drawings.
   1. Provide blocking, stiffeners and bridging for lateral support of members, to provide nailing surface for sheathing and finish materials and to fireblock cavities in accordance with California Building Code (CBC) requirements.
   2. Provide one row of bridging at mid-span for spans over 16 feet, where joist depth is 16-inches or greater or where live load exceeds 40 pounds per square foot.

F. Field Cutting and Modifications: Do not alter wood joists in field except as permitted for penetrating elements such as piping and conduit.
   1. Comply with details shown on the Drawings and according to applicable ICC Evaluation Service, Inc. (ICC ES) Research Report, including conditions of acceptance by the Division of the State Architect (DSA).
2. Do not repair damaged or defective joists. Joists which are damaged or found to not conform to specified requirements shall be rejected and immediately removed from the Project site. Provide new joists at no change in Contract Time and Contract Sum.

END OF SECTION 06174
SECTION 06181 - GLUE LAMINATED STRUCTURAL UNITS

PART I - GENERAL

1.1 SECTION INCLUDES:

A. Glue laminated wood beams.
B. Related steel framing hardware and attachment brackets.

1.2 RELATED SECTIONS

A. Section 01450 - Quality Control: Tests and inspections for glue-laminated structural units.
B. Section 05505 - Miscellaneous Metal Fabrications: Custom fabricated metal framing anchors.
C. Section 03200 - Reinforcing Steel: Embedding anchors and brackets for glue laminated wood members.
D. Section 06112 - Wood Framing and Sheathing: General requirements applicable also to glue laminated wood members.
E. Section 06172 - Metal-Web Wood Joists: Manufactured wood framing members.
F. Section 06174 - Wood I-Joists: Manufactured wood framing members.
G. Section 09905 - Field Painting: Field finishing of exposed glue laminated structural units.

1.3 SUBMITTALS

A. Shop Drawings: Indicate pertinent dimensions, camber, grades, shop applied finishes, cuts and drilled holes, fasteners, erection details and connection materials and finishes.
B. Certificates of Compliance: Certify compliance with AITC 110-83, PS 56, ANSI/AITC Standard A190.1 and ASTM D3737

1.4 QUALITY ASSURANCE

A. Manufacturer: Certified by American Institute of Timber Construction (AITC)
B. Industry Standard: Comply with ANSI/AITC A 190.1 - Structural Glued Laminated Timber
C. Regulatory Requirements: Members shall be fabricated and inspected in accordance with the requirements of California Building Code (CBC), Section 2312A.6 and Section 2327A.1
   1. All structural glued laminated members shall be continuously inspected during fabrication by a inspector specifically approved for this purpose by Division of the State Architect (DSA)
   2. AITC Certificate will not satisfy this requirement
D. Industrial Standards: Fabrication shall comply with the following standards
   1. ANSI/AITC A190.1 - Structural Glued Laminated Timber.
   2. ASTM D3737 – Structural Glu-Laminated Timbers, Softwood and Hardwood Species

E. Manufacturer Qualification: Provide factory-glued structural units, produced by an AITC-Licensed firm qualified to apply the AITC Quality Inspected mark

F. Product Identification: Each structural glu-laminated member shall be stamped with an identifying number accompanied by a certificate of inspection showing the grade and species of lumber, type of glue and other required information. Certificate shall bear a signed statement by the inspector that the Work has been executed in strict accordance with the approved Drawings and Specifications

1.5 DELIVERY, STORAGE AND HANDLING

A. Protection: Protect members in accordance with AITC requirements.
   1. Piece-mark and wrap structural units before shipping to jobsite
   2. Maintain wrapping until units are in place and ready to receive adjoining framing members
   3. For members to be exposed to view, individually wrap members
   4. For members to be concealed, bundle wrap or load wrap members

B. Storage: Comply with AITC requirements. Protect members from weather and damage during transportation, erection, and construction.
   1. Schedule the delivery and the erection of glued laminated timber to avoid extended on-site storage, and delaying subsequent work.
   2. Store units on sleepers above ground
   3. Slit bottom of wrappings intermittently to allow moisture to escape

PART II - PRODUCTS

2.1 GLUE LAMINATED WOOD STRUCTURAL UNITS

A. Wood Species for Glue Laminated Wood Structural Units:
   1. Lumber for members not exposed to weather: Douglas fir-larch lumber conforming to WCLIB or WWPA grading standards
   2. Lumber for members exposed to Weather: Alaskan Cedar (Pacific Coast Yellow), also known as Alaskan Yellow Cedar (Chamaecyparis Nootkatensis), heartwood

B. Moisture Content of Lumber Not less than 7 percent and not more than 16 percent at time of gluing

C. Range of moisture content in various laminations assembled into single member shall not exceed 5 percent.

D. Comply with California Building Code (CBC) Section 2312A.6.3.

E. Adhesive: ASTM D2559, for wet condition of service. Storage life, mixing, spreading, pot life, working life and assembly time shall comply with ANSI/AITC Standard A190.1

F. End Sealer: Manufacturer's standard, transparent, colorless wood sealer, effective in retarding transmission of moisture at cross-grain cuts
G. Penetrating Sealer: Manufacturer's standard, translucent, penetrating wood sealer, that will not interfere with application of wood stain and transparent finish as specified in Section 09905 – Field Painting.

2.2 CONNECTORS AND ANCHORS

A. Connectors, Anchors, and Accessories: Provide stock- and custom-fabricated connectors of structural steel (ASTM A36) shapes, plates and bars, welded into assemblies of types and sizes indicated, with steel bolts (ASTM A307), lag bolts, and other fasteners, as indicated and as necessary. Conform to general fabrication and fastener requirements specified in Section 05090 Anchors and Fasteners.

B. Framing connectors:
   1. Specified Manufacturer: Simpson Strong-Tie Co., Pleasanton, CA (510/460-9912 or 800/9995099).
   2. Acceptable Manufacturers: None identified. Equivalent products of other manufacturers will be considered in accordance with the substitution provision specified in Section 01600 Product Requirements.
   3. Heavy framing connectors: Simpson Strong-Tie Connectors, formed of steel plate or heavy gauge steel sheet, catalog number as indicated on the Drawings and to suit Project conditions. Provide custom or special-order framing connectors as necessary to suit Project conditions and as indicated on the Drawings.
      a. Stock framing connectors: Simpson - Strong Tie Connectors, catalog number as indicated on the Drawings and to suit Project conditions.
      b. Custom framing connectors: Fabricated as indicated on Drawings and as specified in Section 05505 - Miscellaneous Metal Fabrications.
   4. Finish, concealed locations and dry interior exposed locations: Shop coated with rust-inhibitive primer finish, 2 mils (0.05 mm) minimum dry film thickness.
   5. Finish, exterior locations and damp interior exposed locations: Hot dipped galvanized according to ASTM A123, 1.25 ounces per square foot.

C. Machine Bolts: Size as indicated on the Drawings, ASTM A307, hex head and nut, full bearing on unthreaded shank, length for maximum 1-1/2 inch beyond nut, with steel washer under head and nut.
   1. Concealed locations and dry interior exposed locations: Primer painted with rust-inhibitive primer, 2 mils (0.05 mm) dry film thickness. Coordinate primer with requirements specified in Section 09905 - Field Painting.
   2. Damp interior exposed locations: Electro-galvanized finish.
   3. Exterior locations and damp interior exposed locations: Hot dipped galvanized according to ASTM A123.

2.3 FABRICATION:

A. Glue Laminated Wood Structural Units, General: Provide units with properties as follows, unless otherwise indicated on Drawings. See Structural Drawings for additional requirements.
   1. Members not exposed to view and not exposed to weather: Douglas fir, Industrial appearance grade, Service Grade 24F-V8. Simple span members may be 24F-V4.
   3. Members exposed to view and not protected by roof: Alaskan Yellow Cedar, Architectural appearance grade, Service Grade 20E-V12.

1. Field verify dimensions and Project conditions before fabrication.
2. Each lamination shall be graded on the basis of the requirements of the nominal size of the individual lamination. When lumber is resawn, regrade members on basis of new net size, at no change in Contract Time and Contract Sum. Comply with UBC Standard 25.10090).
3. Provide pre-glued, plain scarf end joints in laminations.
   a. Portions of scarfs in adjacent laminations shall be separated by a minimum of 6-inches.
   b. Strength reducing defects such as wane will not be acceptable in or near an end joint
   c. Sum of knots, which appear in the beveled surface of a scarf, shall not exceed one-fourth the nominal width of lamination when lamination is 1-5/8 inch or less in thickness. Standard "peg-scarf" and "finger joints" and other types of joints not approved by Division of the State Architect (DSA) shall not be used.
4. Provide pre-glued edge joints. For lumber stock glued edge-wise and used in top or bottom lamination of glue laminated units for exterior use or when direction of load is parallel to wide face of the lamination.
   a. For lumber stock used in other laminations, laminations may consist of two or more pieces placed side-by-side, provided longitudinal edge joints in adjacent laminations are staggered at least 2-inches laterally
5. Cut and fit members accurately to length to achieve tight joint fit.
6. Fabricate members with camber built in. Provide camber as indicated on Drawing
7. Do not splice or join members in locations other than those indicated, without approval of Architect (Structural Engineer).

C. Sealing: After end trimming, seal exposed members and members exposed to wet or damp conditions, in accordance with AITC requirements.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordination and Sequencing: Coordinate and sequence glue laminated units installation and installation details with Work specified in other Sections.
   1. Do not install glue laminated members until supporting construction is in place and is braced and secured.
   2. Ensure proper interface of glue laminated members with adjoining components, to minimize cutting and penetration of glue laminated members and to limit erected glue laminated members to the shortest possible exposure to the elements before closing-in of building envelope.
   3. Coordinate routing of pipes, ducts and conduits to avoid penetrations through glue laminated structural units.

3.2 ERECTION

A. Erection: Erect and secure glue laminated units as indicated on Drawings, the reviewed shop drawings and manufacturer's installation instructions and recommendations.
   1. Space, adjust and align glue laminated members in proper locations before permanently fastening. Align glue laminated members between supports and hold in place with temporary bracing until sheathing is secured in place.
   2. Set members level and plumb, or to indicated slope, in correct positions.
   3. Immediately fasten glue laminated members to supporting construction after setting in proper location. Make connections as erection progresses and before construction loads are imposed on glue laminated members. Use fasteners as indicated on the Drawings.
4. Do not permit temporary construction loads which cause member stresses beyond design limits.

B. Erection Bracing: Provide erection bracing as necessary to keep glue laminated members straight and plumb and to assure adequate lateral support until other framing and sheathing materials have been applied.

C. Field Cutting and Modifications:
   1. Do not alter glue laminated members in field except as permitted for penetrating elements such as piping and conduit.
   2. Do not repair damaged or defective glue laminated members. Glue laminated members which are damaged or found to not conform to specified requirements shall be rejected and immediately removed from the Project site. Provide new glue laminated members at no change in Contract Time and Contract Sum.

3.3 TOLERANCES

A. Framing Members: 1/4-inch maximum from true position.

END OF SECTION 06181
SECTION 06402 – INTERIOR ARCHITECTURAL WOODWORK

1.1 SECTION 06402 - INTERIOR ARCHITECTURAL WOODWORK

A. Provide architectural casework storage cabinets and plastic-laminate surfaces for toilet rooms. All work shall comply with “WIC’s” “Manual for Millwork” for interior grade woodwork construction and finishes. Plastic-laminate colors shall be selected by architect.

END OF SECTION 06402
DIVISION 07 – THERMAL AND MOISTURE PROTECTION

1.1 SECTION 07210 - BUILDING INSULATION
   A. Provide stud cavity wall insulation at interior walls. Thermal batt insulation at walls separating classroom spaces from office areas. “Scrim 2” single layer foil insulation FSK at wood framed roof areas and ployisocyanurate rigid roof insulation at steel framed roof areas.

1.2 SECTION 07411 - METAL ROOF PANELS
   A. Provide tapered ribbed galvanized 22 gage thk. factory-formed metal roof panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attached to support structure at metal canopy areas of new Art Center as indicated on drawings. Paint with color as selected by architect.

1.3 SECTION 07412 - METAL WALL PANELS
   A. Provide boxed ribbed galvanized 22 gage thk. factory-formed metal wall panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attached to support structure at new Art Center as indicated on drawings. Paint with color as selected by architect.

1.4 SECTION 07430 - COMPOSITE ALUMINUM PANEL SYSTEM
   A. Provide prefinished faced composite core building panel system with 4mm aluminum composite material including perimeter extrusions, stiffeners, gaskets, sealants and related flashing attached to support structure. Skins shall be formed from 0.020 inch thk. Alloy 3003-H14. Factory color and finish as selected by architect.

1.5 SECTION 07450 - FIBER-REINFORCED CEMENT SIDING
   A. Provide fiber-reinforced cement panel siding system “rain screen”, sealed at all edges with hydrophobic penetrating sealer at new Art Center. Color to be selected by architect. Provide air space, open joints and primary moisture protection behind panels.

1.6 SECTION 07620 - SHEET METAL FLASHING AND TRIM
   A. Provide roof parapet flashing, two piece 24 ga.
   B. Surface mounted counter flashing similar to at all roof parapets. Provide lead flashing 4 lb./sq.ft. hard tempered at roof drains, 24. ga sheet metal over-flow scuppers, and counter flashings

1.7 SECTION 07720 - ROOF ACCESSORIES
   A. Provide roof curbs, equipment supports, roof access hatches where indicated on drawings. Roof access hatch: 30 inches x 36 inches (no louvers).
1.8  SECTION 07840 - THROUGH PENETRATION FIRESTOPPING AND SMOKE SEALS

A. Provide through penetration firestopping and smoke seals at all penetrations through fire and smoke barriers, including: voids around, pipes, ducts, conduit, cables and wire not in conduit.

1.9  SECTION 07920 - JOINT SEALERS

A. Provide sealant at all interior joints to control moisture, acoustics or for appearance.

END OF DIVISION 07
DIVISION 08 – DOORS

1.1 SECTION 08110 - HOLLOW METAL STEEL DOOR FRAMES
   A. Provide 3'-0" x 8'-0" x wall thickness, cold rolled steel sheet, Welded construction, shop primed. Hollow Metal Steel Door – 3'-0" x 8'-0" x 1 ¾" thk. Grade II, heavy duty seamless design with 0516 inch thick steel sheet faces. Shop Primed.

1.2 SECTION 08125 - PREFINISHED STEEL DOOR FRAMES
   A. Provide 3'-0" x 8'-0" x wall thickness anodized finish aluminum door frames.

1.3 SECTION 08211 - FLUSH WOOD DOORS
   A. Provide 3'-0" x 8'-0" x 1 ¾" solid core. hardwood, vertical grain birch facings, book matched, custom grade. Edge finish to match face veneer, stain and transparent finish. Conform to Woodwork Institute – Manual of Millwork, Section 12.

1.4 SECTION 08305 - ACCESS DOORS AND PANELS
   A. Provide painted flush steel access panels in walls and ceilings where required by code.

1.5 SECTION 08361 - OVERHEAD SECTIONAL DOORS
   A. Provide steel sectional overhead doors at locations called for on drawings. Provide view lites are shown on plans

1.6 SECTION 08410 - ALUMINUM ENTRANCES AND STOREFRONTS
   A. Provide 2” x 6” center glazing system, clear anodized finish aluminum storefront and glass standard narrow style aluminum door. Bottom rail is 10 Inches high. 3’-0” x 8’-0” x 1 ¾” thick.

1.7 SECTION 08710 - DOOR HARDWARE
   A. Provide all door hardware for wood and metal doors, storefront and entrance door hardware installation with brushed stainless steel finish as needed.
1.8 SECTION 08800 - GLASS AND GLAZING

A. All glass to be 1” insulated float reflective glazing, fully tempered where required by code or manufacturers requirements.

END OF DIVISION 08
DIVISION 09 – FINISHES

1.1 SECTION 09110 - LIGHT GAGE METAL FRAMING
A. Interior metal stud wall framing and furring for gypsum board attachment, interior soffit and ceiling framing for gypsum board attachment. Related backing and bridging. Framing members to be ASTM C 645, minimum yield strength 33 ksi.

1.2 SECTION 09250 - GYPSUM BOARD
A. All interior partitions soffits or ceilings shall receive 5/8” gyp. bd. All joints will be taped, mudded and sanded before paint. Provide Type “X” as required for fire rated conditions. Provide impact resistant gypsum board in high trafficked/impact areas.

1.3 SECTION 09310 - CERAMIC TILE
A. All walls of restrooms to received 48 inch high ceramic tile wainscot.

1.4 SECTION 09510 - ACOUSTICAL PANEL CEILINGS
A. Provide suspension grid 24” x 48” 15/16 inches. Exposed intermediate duty. Acoustical panels 24” x 48” x 3/4” thick, finish-white, lay-in.

1.5 SECTION 09650 - RESILIENT FLOORING
A. All Facility Support Room floors shall receive resilient flooring. Resilient flooring to be Vinyl Composition Tile (VCT), color to be selected from full range of colors. Provide 6” coved sheet vinyl base.

1.6 SECTION 09680 – CARPET
A. All office area rooms only are to be carpeted with rubber base. Direct Glu-down. Color to be selected by Architect.

1.7 SECTION 09910 - FIELD PAINTING
A. Prime and finish paint all exposed surfaces of new construction unless noted otherwise.
B. Interior work to be painted: room walls, columns, gypsum board walls, soffits and ceilings, walls to be painted to 6 inches above ceilings, wood doors if not factory finished, steel door frames if not factory finished.
C. Exterior work to be painted: All exposed exterior items and surfaces as noted on drawings except “honed, split-face and scored precision CMU, fiber-cement cladding and aluminum composite panels. Paint all
exterior steel, trash enclosure walls, gates, bollards, exposed bare and covered pipes and ducts. Exposed steel and Iron work not in view shall be primed metal surfaces including all mechanical equipment.

D. All surfaces to receive 3 coat painting system. (1) coat appropriate primer with (2) coats finish paint (Semi-Gloss, Flat, etc) with system selected for material to be painted (Plaster, Gypsum Board etc.) Colors to be selected by Architect.

END OF DIVISION 09
DIVISION 10 – SPECIALTIES

1.1 SECTION 10101 - VISIBLE DISPLAY SURFACES
   A. Provide and install all marker “whiteboards” with porcelain-enamel face sheet. Color, size and style to be selected by Architect.

1.2 SECTION 10155 - TOILET COMPARTMENT
   A. Provide and install all floor supported metal toilet compartments for toilet rooms. Color and style to be selected by Architect.

1.3 SECTION 10801 - TOILET ACCESSORIES
   A. Provide and install all accessories for toilet rooms. Accessories shall including toilet tissue dispensers, toilet seat cover dispensers, feminine napkin dispenser, soap dispensers, paper towel dispenser, paper towel disposal, feminine napkin disposal, mirrors

END OF DIVISION 10
SECTION 15010 – BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. Basic mechanical requirements specifically applicable to Division 15 Sections.

B. Work includes but is not necessarily limited to the following:

1. Labor, materials, services, equipment, and appliances required for completion of tasks as indicated on drawing or in specification or as inherently necessary to prepare spaces and systems for new installations as follows:

   a. Heating, ventilating and air conditioning systems and equipment
   b. Plumbing systems and equipment
   c. Testing, adjusting and balancing

1.2 DRAWINGS AND SPECIFICATIONS

A. Drawings accompanying these Specifications show intent of Work to be done. Specifications shall identify quality and grade of installation and where equipment and hardware is not particularly specified, Contractor shall provide submittals for all products and install them per manufacturers’ recommendations, and in a first class manner.

B. Examine Drawings and Specifications for elements in connection with this Work; determine existing and new general construction conditions and be familiar with all limitations caused by such conditions.

C. Plans are intended to show general arrangement and extent of Work contemplated. Exact location and arrangement of parts shall be determined after the University has reviewed equipment, as Work progresses, to conform in best possible manner with surroundings, and as directed by the University’s Representative.

D. Contract Documents are in part diagrammatic and intended to show the scope and general arrangement of the Work under this Contract. The Contractor shall follow these drawings in laying out the equipment, piping and ductwork. Drawings are not intended to be scaled for roughing in measurements or to serve as shop drawings. Where job conditions require minor changes or adjustments in the indicated locations or arrangement of the Work, such changes shall be made without change in the Contract amount.

E. Follow dimensions without regard to scale. Where no figures or notations are given, the Plans shall be followed.

1.3 UTILITIES

A. Location and sizes of electrical, mechanical and plumbing service facilities are shown in accordance with data secured from existing record drawings and site observations. Data shown are offered as an estimating guide without guarantee of accuracy. Check and verify all data given, and verify exact location of all utility services pertaining to Work prior to excavation or performing Work.
1.4 UNIVERSITY FURNISHED PRODUCTS

A. Unless noted otherwise, all items shall be furnished by the Contractor for a complete and operational installation.

1.5 APPLICABLE REFERENCE STANDARDS, CODES AND REGULATIONS:

A. Meet requirements of all state codes having jurisdiction.

B. State of California Code of Regulations:

1. Title 8, Industrial Relations
2. Title 19, State Fire Marshal Regulations
3. 2007 California Building Code (CBC), Title 24, Part 2
4. 2005 California Electrical Code, Title 24, Part 3
5. 2007 California Mechanical Code, Title 24, Part 4
6. 2007 California Plumbing Code, Title 24, Part 5
7. 2007 California Fire Code, Title 24, Part 9
8. 2007 California Standards Code, Title 24, Part 12
9. Title 24, Energy Conservation Standards

C. Additional Referenced Standards:

- AABC Associated Air Balance Council
- AMCA Air Moving and Conditioning Association
- ARI Air-Conditioning and Refrigeration Institute
- ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
- ASME American Society of Mechanical Engineers
- ASTM American Society for Testing and Materials
- NEMA National Electrical Manufacturer’s Association
- NFPA National Fire Protection Association Standards
- PDI Plumbing and Drainage Institute
- UL Underwriters Laboratories, Inc.

D. Codes and ordinances having jurisdiction over Work are minimum requirements; but, if Contract Documents indicate requirements which are in excess of those minimum requirements, then requirements of the Contract Documents shall be followed. Should there be any conflicts between Contract Documents or codes or any ordinances having jurisdiction, report these to the University’s Representative.

E. Obtain permits, and request inspections from authority having jurisdiction.

1.6 PROJECT/SITE CONDITIONS

A. The arrangement of and connection to equipment shown on the drawings is based upon information available and is not intended to show exact dimensions peculiar to a specific manufacturer. The Drawings are, in part, diagrammatic and some features of the illustrated equipment installations may require revision to meet actual equipment installation requirements. Structural supports, housekeeping pads, piping connections and adjacent equipment may have to be altered to accommodate the equipment provided. No additional payment will be made for such revisions or alterations.

B. Examine all Drawings and Specifications to be fully cognizant of all work required under this Division.
C. Examine site related work and surfaces before starting work of any Section.

D. Install Work in locations shown on approved Drawings, unless prevented by Project conditions.

E. Prepare revised shop drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission from the University’s Representative before proceeding.

F. Beginning work of any Section constitutes acceptance of conditions.

1.7 COOPERATION WITH WORK UNDER OTHER DIVISIONS

A. Cooperate with other trades to facilitate general progress of Work. Allow all other trades every reasonable opportunity for installation of their work.

B. Work under this Division shall follow general building construction closely. Set pipe sleeves and inserts and verify that openings for chases and pipes are provided.

C. Work with other trades in determining exact location of outlets, pipes, and pieces of equipment to avoid interference with lines required to maintain proper installation of Work.

D. Make such progress in the Work to not delay work of other trades.

E. Mechanical Work shall have precedence over the other in the following sequence:

1. Soil and waste piping
2. Hydronic piping
3. Ductwork
4. Fire sprinkler piping
5. Domestic water piping

1.8 DISCREPANCIES

A. The Contractor shall check all Drawings furnished him immediately upon their receipt and shall promptly notify the University of any discrepancies. Figures marked on Drawings shall in general be followed in preference to scale measurements. Piping and instrumentation diagrams shall in general govern floor plans and sections. Large-scale drawings shall in general govern small-scale drawings. The Contractor shall compare all drawings and verify the figures before lying out the work and will be responsible for any errors, which might have been avoided thereby.

B. Where requirements between Drawings and Specifications conflict, the more restrictive provisions shall apply.

C. If any part of the Specifications or Drawings appears unclear or contradictory, apply to University’s Representative for interpretation and decision as early as possible, including during bidding period. Do not proceed with such work without University’s decision. Beginning work of any Section constitutes acceptance of conditions.
1.9 CHANGES

A. The Contractor shall be responsible to make and obtain approval from the University Representative for all necessary adjustments in piping and equipment layouts as required to accommodate the relocations of equipment and/or devices, which are affected by any approved authorized changes or Product substitutions. All changes shall be clearly indicated on the "Record" drawings.

1.10 SUBMITTALS

A. The manufacturer, contractor or supplier shall include a written statement that the submitted equipment, hardware or accessory complies with the requirement of that particular specification section. The manufacturer shall resubmit the specification section showing compliance with each respective paragraphs and specified items and features in that particular specification section. All exceptions shall be clearly identified by referencing respective paragraph and other requirements along with proposed alternative.

B. Note that prior to acceptance of shop drawings for review, a submittal schedule shall be submitted to the University’s Representative.

C. Submit all Division 15 shop drawings and product data grouped and referenced by the specification technical section numbers in one complete submittal package. Individual submittal packages, submitted at different times will not be reviewed and returned to the contractor.

D. Shop Drawings: Drawings shall be a minimum of 8.5 inches by 11 inches in size with a minimum scale of 1/4-inch per foot, except as specified otherwise. Include installation details of equipment indicating proposed location, layout and arrangement, accessories, piping, and other items that must be shown to assure a coordinated installation. Indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, revise drawings to show acceptable equipment and resubmit. All shop drawings shall be generated in AutoCAD, latest version.

E. Whenever more than one (1) manufacturer’s product is specified, the first named product is the basis of design used in the Work and the use of alternate-named manufacturer’s products or substitutes may require modifications in that design. If such alternatives are proposed by the Contractor, there may be additional design work required. Within 15 days of the submittal of a proposed alternate, as presented in the Contractor’s submittal, the architect and engineers will provide the design fees to modify the issued drawings for the work to incorporate that alternate into the documents. The contractor shall assume all costs required to make necessary revisions and modifications to the design, including all professional fees to the Architect and Engineers for the evaluation and revisions or modifications of the documents resulting from the substitution or selection of an alternate manufacturer submitted by the Contractor.

F. All submittals must be turned in to the General Contractor and/or University within 30 days of the award to the Subcontractor. Failure to submit any or all items shall not result in a delay in the schedule or a schedule extension. If more time is required to compile a specific submittal, then a formal request in writing may be submitted, requesting more time. This request should list the item or system, the CSI Division Section, the reason for the delay, and the date when this item will be submitted. This will be reviewed by the Contractor and Architect and a response will be prepared within one week. Selection of alternates or substitutions can significantly affect the design, especially with regard to appearance, performance, and integration with other elements. All criteria must be evaluated to maintain the integrity of the design as approved by the University and the University’s Representatives.

G. Proposed Products List: Include Products as required by the individual section in this Division.
H. The Contractor shall be responsible for all equipment ordered and/or installed prior to receipt of shop drawings returned from the University’s Representative bearing the University’s Representative stamp of "Reviewed". All corrections or modifications to the equipment as noted on the shop drawings shall be performed and equipment removed from the job site at the request of the University’s Representative without additional compensation.

I. Manufacturer's Data: For each manufactured item, provide current manufacturer's descriptive literature of cataloged products, certified equipment drawings, diagrams, performance and characteristic curves if applicable, and catalog cuts.

J. Standard Compliance: When materials or equipment provided by the Contractor must conform to the standards of organizations such as American National Standards Institute (ANSI) or American Water Works Association (AWWA), submit proof of such conformance to the University for approval. If an organization uses a label or listing to indicate compliance with a particular standard, the label or listing will be acceptable evidence, unless otherwise specified. In lieu of the label or listing, submit a certificate from an independent testing organization, which is competent to perform acceptance testing and is approved by the University. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard.

K. Certified Test Reports: Before delivery of materials and equipment, certified copies of all test reports specified in individual sections shall be submitted for approval.

L. Certificates of Compliance or Conformance: Submit manufacturer's certifications as required on products, materials, finish, and equipment indicated in the technical sections. Certifications shall be documents prepared specifically for this Contract. Pre-printed certifications and copies of previously submitted documents will not be acceptable. The manufacturer's certifications shall name the appropriate products, equipment, or materials and the publication specified as controlling the quality of that item. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; or "achieve the same end use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material." Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance or conformance.

1.11 PRODUCT ALTERNATIVES OR SUBSTITUTIONS

A. Submit for review.

1.12 GUARANTEE

A. Except as may be specified under other sections in the Specifications, guarantee all equipment furnished under the Specifications for a period of one year from date of project acceptance against defective workmanship and material and improper installation. Upon notification of failure, correct deficiency immediately and without cost to the University.

B. Standard warranty of manufacturer shall apply for replacement of parts after expiration of the above period. Manufacturer shall furnish replacement parts to the University for their service agency as directed.
1.13 OPERATION AND MAINTENANCE MANUAL

A. Format:

1. Prepare data in the form of an instructional manual.
2. Binders:
   a. Commercial quality, 8-1/2 x 11 inch three-ring binders with hardback, cleanable, plastic covers; one inch maximum ring size.
   b. When multiple binders are used, correlate data into related consistent groupings.
3. Cover:
   a. Identify each binder with typed or printed title OPERATION AND MAINTENANCE INSTRUCTIONS; list title of Project and separate building; identify subject matter of contents.
4. Arrange content by systems and process flow under section numbers and sequence of Table of Contents of this Project Manual.
5. Provide tabbed fly leaf for each separate product and system, with typed description of product and major component parts of equipment.
6. Text:
   a. Manufacturer's printed data, or typewritten data on 20 pound paper.
7. Drawings:
   a. Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.

B. Contents, Each Volume (Provide 4 copies)

1. Table of Contents: Provide title of Project; names, addresses, and telephone numbers of the Engineer, and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.
2. For Each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.
3. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.
4. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams.
5. Type Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

C. Manual for Equipment and Systems

1. Each Item of Equipment and Each System: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.
2. Panelboard Circuit Directories: Provide electrical service characteristics, controls and communications.
3. Include color coded wiring diagrams as installed.
4. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions. Include summer, winter, and any special operating instructions.
5. Maintenance Requirements: Include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
6. Provide servicing and lubrication schedule, and list of lubricants required.
7. Include manufacturer's printed operation and maintenance instructions.
8. Include sequence of operation by controls manufacturer.
9. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
10. Provide control diagrams by controls manufacturer as installed.
11. Provide Contractor's coordination drawings, with color coded piping diagrams as installed.
12. Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
13. Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
15. Provide a listing in Table of Contents for design data, with tabbed fly sheet and space for insertion of data.

1.14 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation and maintenance personnel.

B. The operating instructions shall include control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions as directed. Attach or post operating instructions adjacent to each principal system and equipment. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.15 INSTRUCTION TO THE UNIVERSITY PERSONNEL

A. Provide training as specified in individual sections.

B. Before final inspection, instruct the University’s designated personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon times. Furnish the services of competent instructors to give full instruction to the University personnel in the adjustment, operation, and maintenance of systems and equipment, including pertinent safety requirements. Each instructor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

C. The amount of time required for instruction on each item of equipment and system is that specified in individual sections.

D. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with the University’s personnel in detail to explain all aspects of operation and maintenance.
E. Contractor shall video tape all in service training and instruction sessions and provide DVD, properly indexed, for training additional and future maintenance personnel.

F. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

G. Submit six copies of Manufacturer’s Instruction Certificates as specified in individual specification Sections.

1.16 MANUFACTURER'S RECOMMENDATIONS

A. Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the item shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material.

1.17 DELIVERY AND STORAGE

A. Handle, store, and protect equipment and materials in accordance with the manufacturer's recommendations and with the requirements of NFPA 70B P, Appendix I, titled "Equipment Storage and Maintenance During Construction." Replace damaged or defective items with new items.

1.18 EXTRA MATERIALS

A. Unless otherwise specified, spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words “spare parts.” A neatly type inventory of spare parts shall be taped to the underside of the cover.

1.19 PROJECT RECORD DOCUMENTS

A. Maintain on site, one set of the following record documents; record actual revisions to the Work:

2. Specifications.
3. Addenda.
4. Change Orders and other Modifications to the Contract.
5. Reviewed shop drawings, product data, and samples.

B. Store Record Documents separate from documents used for construction. Record documents shall be available for review by the Construction Inspector and Engineer at all times.

C. Record information concurrent with construction progress.
D. 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.

E. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:
   1. Field changes of dimension and detail.
   2. Details not on original Contract Drawings.

F. All changes and information recorded on the set of prints maintained during the Work shall be neatly drawn and printed on a new set of plans in an orderly and legible manner, using approved permanent materials and methods. Any additional sheets necessary to complete the record drawings shall be provided by the Contractor and shall be of the same size, borderline, titling identification, and media as the record drawings.

G. Submit completed documents to the University prior to Completion.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 GENERAL
   A. Obtain and pay for all permits and inspections, including any independent testing required to verify standard compliance, and deliver certificates for same to the University.

3.2 WORK RESPONSIBILITIES
   A. The drawings indicate diagrammatically the desired locations or arrangement of piping, equipment, etc., and are to be followed as closely as possible. Proper judgment must be exercised in executing the work so as to secure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference with structural conditions.
   
   B. The Contractor is responsible for the correct placing of Work and the proper location and connection of Work in relation to the work of other trades. Advise appropriate trade as to locations of access panels.
   
   C. In the event changes in the indicated locations or arrangements are necessary, due to developed conditions in the building construction or rearrangement of furnishings or equipment, such changes shall be made without extra cost, providing the change is ordered before the ductwork, piping, etc. and work directly connected to same is installed and no extra materials are required.
   
   D. Where equipment is furnished by others, verify dimensions and the correct locations of this equipment before proceeding with the roughing-in of connections.
E. All scaled and figured dimensions are approximate of typical equipment of the class indicated. Before proceeding with any work, carefully check and verify all dimensions, sizes, etc. with the drawings to see that the equipment will fit into the spaces provided without violation of applicable codes.

F. Should any changes to the Work indicated on the Drawings or described in the Specifications be necessary in order to comply with the above requirements, notify the University immediately and cease work on all parts of the contract, which are affected until approval for any required modifications to the construction has been obtained from the University.

G. Be responsible for any cooperative work, which must be altered due to lack of proper supervision or failure to make proper provisions in time. Such changes shall be under direction of the University and shall be made to his satisfaction. Perform all Work with competent and skilled personnel.

H. All work, including aesthetic as well as mechanical aspects of the Work, shall be of the highest quality consistent with the best practices of the trade.

I. Replace or repair, without additional compensation, any work, which, in the opinion of the University, does not comply with these requirements.

3.3 PAINTING

A. Factory Applied: Mechanical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion-resistance test, except equipment specified to meet requirements of ANSI C37.20 shall have a finish as specified in ANSI C37.20. Refer to individual sections of this Division for more stringent requirements.

B. Field Applied: Paint mechanical equipment as required to touch up, to match finish on other equipment in adjacent spaces or to meet safety criteria.

C. Piping, valves, piping supports, hangers and appurtenances shall be painted. Ductwork, roof mounted mechanical equipment, ductwork supports, hangers and appurtenances shall be painted. Refer to Division 9 for additional requirements.

END OF SECTION 15010
PART 1 - GENERAL

1.1 SCOPE

A. Section includes requirements for Contractor’s Site and Utilities Surveys, Site and Utilities Surveys Submittal, University’s Reference Points Survey.

1.2 CONTRACTOR’S SITE AND UTILITIES SURVEYS

A. Contractor shall conduct a site and utility survey using a Land Surveyor or Civil Engineer currently registered in the State of California with a valid license.

B. Contractor shall investigate the Project Site to ascertain all conditions affecting procedures and sequencing of the Work. Working from lines and levels established by the property survey, establish benchmarks and markers to set lines and elsewhere as needed to properly locate each element of the project. Calculate and measure required dimensions within indicated or recognized tolerances. Do not scale drawings to determine dimensions.

1. Utilities in Streets, Easements, and/or Alleys: Contractor is responsible for verifying the conditions under which work on such utilities will be done, such as what lines will be left in place, removed, or rerouted.

2. Contractor shall report to the University’s Representative any adverse condition(s) that may affect the proper execution of the Work. Do not proceed until instructed by the University’s Representative.

3. Contractor shall verify, confirm, and coordinate field measurements so that new construction correctly and accurately interfaces with conditions existing prior to construction.

4. Contractor shall verify locations of survey control points, reference points, and benchmarks prior to starting work.

   a. Locate and protect existing benchmarks and control points.

   b. Preserve permanent reference points during construction.

   c. Contractor shall provide field engineering service using recognized engineering survey practices.

      1) Establish a minimum of one permanent three-inch diameter brass bench mark on site, referenced to established control points. Record locations, with horizontal and vertical data, on Project record documents.

      2) Establish elevations, lines and levels. Locate and layout by instrumentation and similar appropriate means.

      3) Site improvements including pavements, stakes for grading, fill and topsoil placement when applicable, utility locations, slopes, and invert elevations. Locate by instrumentation or similar appropriate means.

      4) Grid or axis for structures.

      5) Building foundation, column locations, ground floor elevations, set-out references. Include batter boards for structures, building foundations, column grids and locations, floor levels and control lines and levels required for mechanical work.

      6) Floor elevations of existing structures, if any, which relate to the Project.

      7) Partition layouts on rough floor as a guide to all trades.
5. Contractor shall verify that utility requirement and characteristics of operating equipment are, compatible with building utilities. Coordinate work of various Specification Sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.

C. Maintain a complete and accurate log of control and survey work as it progresses.

D. On completion of major site improvements, prepare a certified survey illustrating dimensions, locations, angles, and elevations of construction and site work.

1.3 SITE AND UTILITIES SURVEYS SUBMITTAL

A. Submit name, address, license number and telephone number of Surveyor or Civil Engineer before starting survey work.

B. Submit information in 1.2 above to the University’s Representative for review.

1.4 THE UNIVERSITY’S REFERENCE POINTS SURVEY

A. The University will provide survey control and reference points if required.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Periodically verify layouts by same means.

B. Protect survey control points prior to starting site work; preserve permanent reference points during construction.

C. Promptly report to the University the loss or destruction of any reference point or relocation required because of changes in grades or other reasons. Replace lost, destroyed, or dislocated project control points. Base replacements on the original survey control points when possible.

D. Advise entities engaged in construction activities of marked lines and levels provided for their use.

E. As construction proceeds, check every major element for line, level and plumb.

END OF SECTION 15013
SECTION 15060 – PIPE AND PIPE FITTINGS - GENERAL

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies systems and general requirements for piping systems. Detailed specifications for the components listed in this Section are found in other sections of Division 15. This section shall be used in conjunction with those sections.

B. Definitions: Pressure terms used in Section 15060 elsewhere in Division 15 are defined as follows:

1. Maximum: The greatest continuous pressure at which the piping system operates.
2. Test: The hydrostatic pressure used to determine system acceptance.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ANSI A13.1 Scheme for the Identification of Piping Systems.
- ANSI B1.20.1 Pipe Threads, General Purpose (Inch).
- ANSI/ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800.
- ANSI/ASME B16.5 Pipe Flanges and Flanged Fittings.
- ANSI/ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- ANSI/ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.
- ANSI/ASME B31.1 Power Piping
- ANSI/ASME B31.9 Building Services Piping.
- ANSI/AWS D1 Structural Welding Code.
- ASTM A47 Malleable Iron Castings.
- ASTM A53 Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded and Seamless.
- ASTM A74 Cast Iron Soil Pipe and Fittings.
- ASTM A105/A105M Forging, Carbon Steel, for Piping Components.
- ASTM A106 Seamless Carbon Steel Pipe for High-Temperature Service.
- ASTM A269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- ASTM A312 Seamless and Welded Austenitic Stainless Steel Pipes.
- ASTM A570/A570M Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality.
- ASTM B88 Seamless Copper Water Tube.
- ASTM C564 Rubber Gaskets for Iron Soil Pipe and Fittings.
- ASTM D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, 80, 120.
- ASTM D2513 Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
- AWWA C111 Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- AWWA C200 Steel Water Pipe 6 Inches and Larger.
- AWWA C206 Field Welding of Steel Water Pipe.
- AWWA C208 Dimensions for Fabricated Steel Water Pipe Fittings.
- AWWA C600 Installation of Ductile-Iron Water Mains and Their Appurtenances.
B. Fittings and coupling compatibility: To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

C. Welding materials and labor to conform to ASME Code and applicable state labor regulations.

D. Welders shall be fully qualified and certified by an approved welding bureau and state authorities. Each welder shall be required to identify his work with a marking. Mark of welder shall be stamped on each weld joint of pipe, valve or fitting. A listing of the names of the welder, together with corresponding marks, shall be submitted. Welders making defective welds after passing qualification test shall be given a requalification test and upon failing to pass a requalification test shall not be permitted to work on this project.

E. Domestic water, drainage and vent piping per applicable building code for the system type specified herein.

F. Gas piping per Title 24, Part 5, California Plumbing Code and local utility company requirements.

1.3 SUBMITTALS

A. Submit piping shop drawings to the Engineer minimum of 4 weeks prior to construction for all new piping to be installed.

B. Certification:

1. Submit mill certification sheets for all pipe materials prior to delivery or shop fabrication.

C. Welding Documentation:

1. Submit Welding Procedure Specification (WPS) documentation prior to any fabrication activity.
2. Submit Welder Performance Qualification documents that reference the specific WPS to University Representative for all welders and welding operators, shop or field, employed on this Work prior to beginning any fabrication activity.
3. The above documentation is required for welding performed under any ASME B-31 series Code including B-31.9
4. Brazing Documentation:

   a. Submit Brazing and Soldering Procedure Specification documentation prior to any fabrication activity.
   b. Contractor shall submit Brazer/Solderer Performance Qualification documents that reference the specific Brazing and Soldering Procedure Specification to the University Representative for all brazers/solderers and brazing/soldering operators, shop or field, employed on this Work prior to beginning any fabrication activity.
   c. The above documentation is required for brazing performed under any ASME B-31 series Code including B-31.9

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver pipe and tube with factory-applied end caps. Maintain end caps through shipping, storage and handling to prevent pipe-end damage and entrance of dirt, debris and moisture.
B. Upon receipt, the Contractor shall visually inspect every pipe and component and reject items that contain an injurious defect. Injurious defects include internal and external surface gouges, scars, scratches, blisters, or discontinuities that produce a notch effect.

C. Project material shall be stored in an area specifically assigned to this project where exposure to heat, dirt, and contamination are avoided.
   1. Elevate stored pipe and tube above grade to protect from moisture and dirt. When stored within buildings, do not exceed structural capacity of the floor.
   2. Protect stored plastic pipes from direct sunlight.
   3. Support piping to prevent sagging.

1.5 PIPING INSTALLATION

A. Unless otherwise indicated, installation of piping shall be made substantially as indicated on drawings, installed in accordance with the ANSI/ASME Standard Code for Pressure Piping B31.1, latest issue, including anchorage of piping, guides and supports for such piping. Installation of plumbing piping shall be installed in accordance with ANSI/ASME B31.9, latest issue.

B. Drawings: The accompanying drawings are intended for the Contractor’s guidance, and he shall verify their accuracy and immediately notify the Owner of any discrepancies so that such discrepancies may be resolved prior to actual fabrication or installation of work. Minor changes in position of piping as necessary to meet job conditions shall be anticipated by the Contractor and shall not be made the basis for change order. Changes affecting accessibility to or clearance about equipment or accessories shall be promptly communicated to the Owner.

C. Sizes: Sizes and arrangement of piping shall be as shown on the drawings. Conflict or inconsistencies of detail for final connections shall be resolved by the Engineer.

D. Piping Diagrams: Piping diagrams are not for the purpose of giving physical dimensions or locations but rather to make clear the interconnection, by the piping, of the various units of the process. If an item is shown on either the piping diagram or the piping detail drawings, but not on both, it will be assumed that the Contractor has included such item in his estimate of the cost of the work and that he shall install the same.

E. Pipe Lengths: In the assembly of the piping system, the longest available commercial standard piping lengths shall be utilized to minimize number of piping joints. Piping shall be accurately cut to field measurements to permit placement without forcing or springing, except where provisions for cold springing are required.

F. Piping Layout: All piping shall be run straight and parallel with adjacent walls, presenting a uniform and neat appearance.

G. Fittings and Coupling Compatibility: To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturer.

H. Provide drip pans for piping above electrical equipment.
PART 2 - PRODUCTS

2.1 PIPING MATERIAL
   A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, and shall be selected from those listed on the piping system specification sheets.
   B. Piping materials shall conform to detailed specifications for each type of pipe and piping appurtenance specified in other sections of Division 15.

2.2 VALVES AND FLANGES
   A. Valves of the same size and service shall be provided by a single valve manufacturer.
   B. Packing shall be nonasbestos material.
   C. Actual length of valves shall be within 1/16 inch (plus or minus) of the manufacturer’s specified length.
   D. Flanges shall meet the requirement of ANSI/ASME B16.5.
   E. Push-on and mechanical joints shall meet the requirements of AWWA C111.
   F. Valve operators are specified in Section 15185.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Ream pipes and tubes. Clean off scale and dirt, inside and outside, before assembly. Remove welding slag or other foreign material from piping.

3.2 CONNECTIONS
   A. Units and fittings shall be joined with flanges, mechanical joints or integral bell and spigot joints with rubber sealing rings.
   B. Screw joint steel piping up to and including 2”. Weld piping 2-1/2” and larger, including branch connections.
   C. Use full-cut standard taper pipe threads. Make up joints using PTFE tape, Teflon based pipe joint compound, or other approved nontoxic joint compound applied to male threads only.
   D. Use main-sized “Weld-O-Let” or “Thread-O-Let” male branch connections or “Stub-in” in steel piping if main is at least one pipe size larger than the branch for up to 6” mains and main is at least two pipe sizes larger than branch for 8” and larger mains. Do not project branch pipes inside the main pipe.
   E. Joints for cast iron bell and spigot pipe shall have a Neoprene gasketing system. Joint for plain end pipe shall have clamp-type mechanical fasteners and gaskets.
F. Use grooved mechanical couplings only as shown on Drawings. Grooved mechanical couplings are acceptable and equipment connections.

G. Make connections to equipment and branch mains with unions or flanges.

H. Provide nonconducting type connections wherever jointing dissimilar metals in all systems. Brass adapters and valves are acceptable.

I. On copper piping systems, tee drilling shall be permitted for sizes up to and including 1” provided the main service pipe size is a minimum four pipe sizes larger than the size of the tee drill connection.

3.3 ROUTE AND GRADES

A. Route piping in orderly manner and maintain proper grades. Install to conserve headroom and interfere as little as possible with use of space. Run exposed piping parallel to walls. Grouping piping whenever practical at common elevations. Install concealed pipes close to building structure to keep furring to a minimum.

B. Slope water piping above grade 1 inch in 40 feet and arrange to drain at low points.

C. On closed systems, low points shall be provided with 3/4” isolation drain valves and hose nipples at all low points. Provide manual air vents with isolation valves at high points. Provide 1/2” piping from manual air vents to nearest drain location.

D. Make reductions in water pipes with eccentric reducing fittings installed to provide drainage and venting.

E. Grade horizontal drainage and vent piping at minimum 2% slope unless otherwise noted.

F. Install piping to allow for expansion and contraction without stressing pipe or connected equipment.

G. Provide clearance for installation of insulation and for access to valves, air vents, drains and unions.

H. Install same type piping material specified for inside building to 5 feet outside of building.

3.4 IDENTIFICATION

A. Identify piping, flow direction and contents as specified in Section 15190.

3.5 CLEANING

A. Refer to specification section 15547 "Pipe Cleaning" for additional requirements.

3.6 TESTING

A. Refer to specification section 15053 "Pipe Tests" for additional requirements.

B. General: Upon completion of piping, the Contractor shall test the existing and new piping systems. Pressures, media and test durations shall be as specified in paragraph 15060-3.08. Equipment, which may be damaged by the specified test conditions, shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls with in the upper half of the gages range. Unless otherwise specified, the Contractor shall notify the Owner’s representative 48 hours prior to each test.
The Owner’s representative must be present during testing of new and existing piping. Unless otherwise specified, testing, as specified herein, shall include existing piping systems, which connect with new pipe systems. Existing pipe shall be tested to the nearest existing valve. Any piping, which fails the test, shall be repaired. Repair of existing piping will be considered and paid for as extra work and shall be coordinated with the Owner.

C. Complete and test pipe rough in before insulation or other finish work is applied. Covering of work before acceptance is prohibited.

D. Do not test relief valves, pressure-regulating valves, valves, or equipment beyond its rated capacity.

E. The allowable leakage rate for systems tested with air shall be based on a maximum pressure drop of 5 percent of the specified test pressure for the duration of the period. Prior to starting a test interval using air, the air shall be at ambient temperature and specified test pressure.

F. Liquid Systems: Leakage shall be zero at the specified test pressure throughout the specified duration for exposed piping. Leakage for buried insulated piping shall not exceed allowed leakage per AWWA C600.

G. The following table indicates fluid category, pipe and pipe maker background color of each service:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Service</th>
<th>Fluid Category</th>
<th>Pipe Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHWS</td>
<td>Chilled Water Supply</td>
<td>Water</td>
<td>Medium Blue</td>
</tr>
<tr>
<td>CHWR</td>
<td>Chilled Water Return</td>
<td>Water</td>
<td>Medium Blue</td>
</tr>
<tr>
<td>CWR</td>
<td>Condenser Water Return</td>
<td>Water</td>
<td>Light Green</td>
</tr>
<tr>
<td>CWS</td>
<td>Condenser Water Supply</td>
<td>Water</td>
<td>Light Green</td>
</tr>
<tr>
<td>DCW</td>
<td>Domestic Cold Water</td>
<td>Water</td>
<td>Light Grey</td>
</tr>
<tr>
<td>FLTS</td>
<td>Filter Condenser Water Supply</td>
<td>Water</td>
<td>Green</td>
</tr>
<tr>
<td>FLTR</td>
<td>Filter Condenser Water Return</td>
<td>Water</td>
<td>Green</td>
</tr>
<tr>
<td>G</td>
<td>Gas</td>
<td>Gas</td>
<td>Yellow</td>
</tr>
<tr>
<td>HHWS</td>
<td>Heating Hot Water Supply</td>
<td>Water</td>
<td>Medium Yellow</td>
</tr>
<tr>
<td>HHWR</td>
<td>Heating Hot Water Return</td>
<td>Water</td>
<td>Medium Yellow</td>
</tr>
<tr>
<td>ICW</td>
<td>Industrial Water</td>
<td>Water</td>
<td>Dark Grey</td>
</tr>
<tr>
<td>IW</td>
<td>Indirect Waste</td>
<td>Water</td>
<td>Green</td>
</tr>
<tr>
<td>MPG</td>
<td>Medium Pressure Gas</td>
<td>Gas</td>
<td>Yellow</td>
</tr>
<tr>
<td>RV</td>
<td>Refrigerant Vent</td>
<td>Gas</td>
<td>Black</td>
</tr>
<tr>
<td>SS</td>
<td>Sanitary Sewer</td>
<td>Water</td>
<td>Dark Yellow</td>
</tr>
<tr>
<td>V</td>
<td>Sanitary Vent</td>
<td>Air</td>
<td>Green</td>
</tr>
<tr>
<td>W</td>
<td>Sanitary Waste</td>
<td>Water</td>
<td>Dark Yellow</td>
</tr>
</tbody>
</table>
### 3.7 PIPING SERVICES

<table>
<thead>
<tr>
<th>Piping Service:</th>
<th>Chilled Water Supply</th>
<th>Chilled Water Return</th>
</tr>
</thead>
</table>

1. **Test Requirements:**
   a. **Medium:** Water; Refer to 15060-3.6.
   b. **Pressure:** 150 psig for above ground piping.
   c. **Pressure:** 120 psig for underground piping.
   d. **Duration:** 120 minutes

2. **Gasket Requirements:**
   a. **Flange:** Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder.
   b. **Push-on/Mechanical Coupling:** Styrene Butadiene Rubber (SBR)
   c. **Silver Solder/Braze** AWS A5.8; Material shall have 15% minimum silver content.

3. **Exposed Pipe and Valves:** (See drawings for pipe size and valve type).
   a. **Pipe (2” and smaller):** Copper Tube; ASTM B88, Type L, hard drawn.
      Refer to Section 15066.
      Connections shall be silver solder /brazed joint.
      Fittings shall be solder type with threaded adapters for valves.
      All elbows shall be 1-1/2 times diameter, full radius.
      Insulate per Section 15250.

   b. **Valves (2” and smaller):** Ball valves.
      Refer to Section 15102.
      Insulate per Section 15250.

   c. **Pipe (2-1/2” and larger):** Steel; ASTM A53, Type E, Grade B, black, Standard, no lining.
      Refer to Section 15061.
      Connections shall be butt weld or flanged.
      Connections to equipment may be flanged or grooved.
      Insulate per Section 15250.
      Fitting shall be malleable iron, ductile iron, or steel per Section 15061; ends to match pipe.
      All elbows shall be 1-1/2 times diameter, full radius.
      Insulate per Section 15250.

   d. **Valves:** Butterfly valves.
      Refer to Section 15103.
      Globe style silent check valve.
      Refer to Section 15108.
      Insulate per Section 15250.
4. Buried and Encased Pipe and Valves: See drawings for pipe size and valve type.

   a. Pipe (2-1/2” and larger): Valve Pits:
      All piping within valve pits shall be ASTM A53, Type ERW, Grade B, black steel, Schedule 40, no lining, flanged. Refer to Section 15061.
      All pipe fittings shall be flanged ductile iron, which conforms to AWWA C153.
      Piping within valve pits and all fittings shall be insulated per specification section 15250.

   b. Pipe (2-1/2” and Larger): Buried Piping:
      All chilled water buried piping outside the valve pits shall be polyvinyl chloride (PVC) and shall conform to AWWA C900 and AWWA C905 standards.
      Piping for sizes 4” through 12” shall be PVC pressure pipe made from class 12454-A or class 12454-B materials providing a hydrostatic design basis (HDB) of 4000 psi.
      Provide magnetic tracer tape on CHWS pipe.
      PVC pipe outside diameters shall conform to cast-iron-pipe-equivalent (CI) outside diameter dimensions (OD).
      PVC pipe wall thicknesses for pipe sizes up to 12” shall be equivalent to a dimension-ratio (DR) series 18 (150 psi rated).
      One gasket shall be furnished with each length of pipe.
      Pipe shall be pre-insulated per Section 15070.
      See Section 15070 for additional requirements.

   c. Fittings (2-1/2” and Larger): Buried Pipe Fittings:
      All underground pipe fittings shall be ductile iron with mechanical joints, which conforms to AWWA C153.

   d. Pipe (2-1/2” and Larger): Buried Pipe and Fitting Connection:
      Connections shall be unrestrained SBR push-on joints and supported with restraining joints.
      Ends shall be flanged for connection to restraining joints where indicated on plans.
      Long radius elbows (1.5 x diameter) all be provided at all locations.
      See Section 15070 for additional requirements.

   e. Pipe and Fittings:
      Corrosion Protection:
      All Schedule 40 steel pipes and metallic surfaces below grade shall be wrapped with wax tape conforming to AWWA C217 Standards and then insulated per requirements of Section 15250.
      Submit shop drawings for wax tape clearly indicating compliance with AWWA C217 requirements.
      See specification section 15070 for additional requirements.

   f. Valves (2” and smaller):
      Ball valves.
      Insulate per Section 15250.
g. Valves (2-1/2” and larger): Butterfly valves, Type A, see Section 15103. Insulate per Section 15250.

h. Remarks: Manual air vents shall be provided at the high points as specified in paragraph 15515. Exposed piping 2-1/2 inches and larger, has been designed using butt weld and flanged piping.

Remarks: Provide manual air vents with isolation valves at high points. Provide 1/2” piping from manual air vents to nearest drain location. Refer to Section 15515 for manual air vent specifications.
1. Test Requirements:
   a. Medium: Water; Refer to 15060-3.6.
   b. Pressure: 100 psig
   c. Duration: 120 minutes

2. Gasket Requirements:
   a. Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder.
   b. Push-on/Mechanical Coupling: Styrene Butadiene Rubber (SBR)

3. Exposed Pipe and Valves: (See drawings for pipe size and valve type)
   a. Pipe (2” and smaller): Steel; ASTM A53, Type E, Grade B, galvanized, Schedule 40 piping. 
      Refer to Section 15061.
      Connections shall be taper threaded, ANSI B1.20.1.
      Fittings shall be malleable iron, ASTM A197, ANSI B16.3, Class 150, galvanized.
      All elbows shall be 1-1/2 times diameter, full radius.
   b. Valves: Ball valves. 
      Refer to Section 15102.
   c. Pipe (2-1/2” thru 8”): Steel; ASTM A53, Type E, Grade B, black, Schedule 40 no lining.
      Refer Section 15061.
      Connection shall be butt weld or flanged.
      Fittings; malleable iron, ductile iron, or steel per spec Section 15061; ends to match pipe.
      All elbows shall be 1-1/2 times diameter, full radius.
   d. Valve (2-1/2” thru 8”): Butterfly valves.
      Refer to Section 15103.
   e. Pipe (10” and larger): Steel; ASTM A53, Type ERW, Grade B, black, Standard no lining. same as 8”.
      Refer Section 15061.
      Connections shall be butt weld or flanged.
      Fittings; steel, ASTM A234, or fabricated steel, AWWA C208; lining and ends to match pipe.
      All elbows shall be 1-1/2 times diameter, full radius.
   f. Valves: Butterfly valves.
      Refer to Section 15103.

4. Buried Condenser Water Pipe: As indicated on plans, see drawings for pipe size and valve type.
   a. Pipe: Fiberglass pipe, refer to Section 15068.
      Connections shall be adhesive bonded or flanged as indicated on the Drawings.
      Exposed pipe subject to ultraviolet radiation (UV) shall be furnished with a 0.040 inch overwrap of organic veil tape or an exterior resin with an ultraviolet inhibitor.
   b. Valve: Butterfly valves.
      Refer Section 15103.
c. Remarks: Manual air vents shall be provided at the high points as specified in paragraph 15515.
Remarks: Provide manual air vents with isolation valves at high points. Provide 1/2" piping from manual air vents to nearest drain location. Refer to Section 15515 for manual air vent specifications.
Piping Service: Domestic Cold Water  Industrial Cold Water  Sizes 4” and larger, Below Grade

1. Test Requirements:
   a. Medium: Clean water free of debris.
   b. Pressure: Test to conform to AWWA C600, Sec. 4 requirements but not less than 115 psi.
   c. Duration: Test to conform to AWWA C600, Sec. 4 requirements, but not less than 2 hours.

2. Disinfection:
   Disinfect in accordance with AWWA C651. Flush chlorinated water within 24 hours from chlorine induction. Disposal of chlorinated water to comply with AWWA C651, Appendix B.

3. Joint Requirements:
   Restrained Push-On Joints; AWWA C111: Vulcanized styrene butadiene rubber gaskets with corrosion resistant bolts and nuts.

4. Piping Below Grade:
   a. Pipe: Ductile Iron; AWWA C151 centrifugally cast, ductile iron pipe, concrete lining to comply with AWWA C104 requirements, thickness to comply with AWWA C150 requirements. Refer to Section 15065.
   b. Fittings: Ductile Iron; AWWA C110; grey iron fittings may be substituted if not available in ductile iron. Refer to Section 15065.
   c. Corrosion Protection: Polyethylene Encasement; AWWA C105: Polyethylene film conformity to ASTM D-1248 and installed per 5-4.2.1, method “A.” Refer to Section 15065.
   d. Valves AWWA Butterfly Gate Valves; WSP rating shall be 150 or greater. Refer to Section 15101.
Piping Service: Domestic Cold Water
Industrial Cold Water
Sizes 3” and smaller, Below Grade

1. Test Requirements:
   a. Medium: Clean water free of debris, clean dry air, or nitrogen.
   b. Pressure: 150% of working pressure but not less than 150 psi.
   c. Duration: 1 hour with no indication of leakage.

2. Disinfection:
   Disinfect in accordance with AWWA C651. Flush chlorinated water within 24 hours from chlorine in-
   duction. Disposal of chlorinated water to comply with AWWA C651, Appendix B.

3. Joint Requirements:
   a. Silver Solder/Braze: AWS A5.8; Material shall have minimum 2% silver content.

4. Piping Below Grade:
   a. Pipe: Copper Pipe, ASTM B88; Type K, hard drawn. Type K, soft
drawn 1” or smaller is also approved.
   Refer to Section 15066.
   b. Fittings: Wrought Copper, ANSI/ASME B16.22; wrought copper and
copper alloy solder joint pressure fittings.
   Refer to Section 15066.
   c. Corrosion Protection: Polyethylene Encasement; AWWA C105; Polyethylene film
   conforming to ASTM D-1248 and installed per 5-4.2.1, Meth-
   od “A”.
   Refer to Section 15066.
<table>
<thead>
<tr>
<th>Piping Service:</th>
<th>Domestic Cold Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial Cold Water</td>
</tr>
<tr>
<td></td>
<td>Above Grade within the Building</td>
</tr>
</tbody>
</table>

1. Test Requirements:
   a. Medium: Clean water free of debris, clean dry air or nitrogen.
   b. Pressure: 150% of working pressure but not less than 150 psi.
   c. Duration: 1 hour with no indication of leakage.

2. Disinfection:
   Disinfect in accordance with AWWA C651. Flush chlorinated water within 24 hours from chlorine induction. Disposal of chlorinated water to comply with AWWA C651, Appendix B.

3. Joint Requirements:
   b. Threaded: PTFE tape, Teflon based pipe joint compound, or other approved non-toxic pipe joint compounds.
   c. Flange: TFE bonded EPDM, full-face gaskets, ANSI B16.1, Garlock Gylon 3504, or equal.

4. Piping Above Grade Inside Building:
   a. Pipe: Copper Pipe; ASTM B88; Type L, hard drawn.
      Refer to Section 15066.
   b. Fittings: Wrought Copper; ANSI/ASME B16.22; wrought copper and copper alloy solder joint pressure fittings.
      Refer to Section 15066.
Piping Service: | Domestic Cold Water | Industrial Cold Water |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sizes 4” and larger, Above Grade &amp; Outside Building Line</td>
<td></td>
</tr>
</tbody>
</table>

1. Test Requirements:
   a. Medium: Clean water free of debris, clean dry air or nitrogen.
   b. Pressure: 150% of working pressure but not less than 150 psi.
   c. Duration: 1 hour with no indication of leakage.

2. Disinfection:
   Disinfect in accordance with AWWA C651. Flush chlorinated water within 24 hours from chlorine induction. Disposal of chlorinated water to comply with AWWA C651, Appendix B.

3. Joint Requirements:
   b. Threaded: PTFE tape, Teflon based pipe joint compound, or other approved non-toxic pipe joint compounds.
   c. Flange: TFE bonded EPDM, full-face gaskets, ANSI B16.1, Garlock Gylon 3504, or equal.

4. Piping Above Grade:
   a. Pipe: Copper Pipe; ASTM B88; Type L, hard drawn.
      Refer to Section 15066.
   b. Fittings: Wrought Copper; ANSI/ASME B16.22; wrought copper and copper alloy solder joint pressure fittings.
      Refer to Section 15066.
   c. Valves: OS&Y gate valves.
      Refer to Section 15101.
### Piping Service:

<table>
<thead>
<tr>
<th>Heating Hot Water Supply</th>
<th>Heating Hot Water Return</th>
</tr>
</thead>
</table>

1. **Test Requirements:**
   a. **Medium:** Water; Refer to Section 15060-3.6.
   b. **Pressure:** 100 psig
   c. **Duration:** 120 minutes

2. **Gasket Requirements:**
   a. **Flange:** Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder.
   b. **Push-on/Mechanical Coupling:** EPDM.

3. **Exposed Pipe and Valves:**
   a. **Pipe (2” and smaller):** Copper Tube; ASTM B88, Type L, drawn. Refer to Section 15066. Connections shall be connected via ProPress Method or pressure rated solder joint. Fittings shall be solder type with threaded adapters for valves. All elbows shall be 1-1/2 times diameter, full radius. Insulate per Section 15250.
   
   b. **Valves (2” and smaller):** Ball valves, refer to Section 15102. Insulate per Section 15250.
   
   c. **Pipe (2-1/2” and larger):** Steel; ASTM A53, Seamless, Grade B, black, no lining. Refer to Section 15061. Connection shall be butt weld or flanged. Fittings shall be malleable iron, ductile iron, or steel per spec Section 15061; ends to match pipe. All elbows shall be 1-1/2 times diameter, full radius. Insulate per Section 15250.
   
   d. **Valves (2-1/2” and larger):** Butterfly valves, refer to Section 15103. Insulate per Section 15250.
### Test Requirements:
- **Medium:** Water, refer to specification section 15060.
- **Pressure:** 150 psig
- **Duration:** 120 minutes

### Gasket Requirements:
- **Flange:** TFE bonded EPDM, full-face gaskets, ANSI B16.1, Garlock Gylon 3504, or equal (no known equal).
- **Push-on/Mech Cpl:** N/A

### Exposed Pipe and Valves:
- **Pipe (All sizes):** CPVC pipe conforming to ASTM D1784, Class 12454-B, ASTM D1785, Schedule 80. Refer to Section 15064. Connections shall be plain end, solvent weld, or flanged for valves 3 inch and larger. Fittings shall be PVC, Schedule 80, solvent weld. All elbows shall be 1-1/2 times diameter, full radius.
- **Valves:** Ball, CPVC.
<table>
<thead>
<tr>
<th>Piping Service:</th>
<th>Indirect Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Test Requirements:</td>
<td>Clean water free of debris.</td>
</tr>
<tr>
<td>a. Medium:</td>
<td>Visual Inspection</td>
</tr>
<tr>
<td>b. Test:</td>
<td></td>
</tr>
<tr>
<td>3. Piping 1” and smaller:</td>
<td></td>
</tr>
<tr>
<td>a. Pipe:</td>
<td>Copper Pipe; ASTM B88; Type L, hard drawn. Type L soft drawn 1/2” or smaller is approved. Ref. spec Section 15066. Pipe shall be insulated if located above ceiling space per specification section 15250.</td>
</tr>
<tr>
<td>b. Fittings:</td>
<td>Wrought Copper; ANSI/ASME B16.22; wrought copper and copper alloy solder joint pressure fittings. Refer to Section 15066. Insulate per Section 15250.</td>
</tr>
<tr>
<td>3. Piping 1-1/4” and larger:</td>
<td></td>
</tr>
<tr>
<td>a. Pipe:</td>
<td>Copper Pipe; ASTM B306; Type DWV, hard drawn. Refer to Section 15066. Insulate per Section 15250.</td>
</tr>
<tr>
<td>b. Fittings:</td>
<td>Wrought Copper; ANSI B16.29 &amp; ANSI B16.23; wrought copper and copper alloy solder joint drainage fittings. Insulate per Section 15250.</td>
</tr>
</tbody>
</table>
### Piping Service: Natural Gas, Medium Pressure (5 PSI)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Test Requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>a. Medium</td>
<td>Clean dry air, CO₂, or Nitrogen.</td>
</tr>
<tr>
<td>b. Pressure</td>
<td>1-1/2 times normal work pressure; not less than 100 psi.</td>
</tr>
<tr>
<td>c. Duration</td>
<td>1 hour with no indication of leakage.</td>
</tr>
<tr>
<td>d. Holiday</td>
<td>All piping below grade shall be electronically tested for defects using a holiday detector (10,000 V. min.)</td>
</tr>
<tr>
<td><strong>2. Joint Requirements:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All connections shall be electrical resistance welded with the exception of flanged connections. Flanges and flange gaskets shall be provided in accordance with NFPA 54, 2.6.10 and 2.6.11.</td>
</tr>
<tr>
<td><strong>3. Piping Above Grade:</strong></td>
<td></td>
</tr>
<tr>
<td>a. Pipe</td>
<td>Steel; ASTM A53, Seamless, Grade B, black, no lining. Refer to Section 15061.</td>
</tr>
<tr>
<td>b. Fittings</td>
<td>Steel; ASTM A234: Schedule 40 with plain or beveled ends. Refer to Section 15061.</td>
</tr>
<tr>
<td><strong>4. Piping Below Grade:</strong></td>
<td></td>
</tr>
<tr>
<td>a. Pipe</td>
<td>Steel; ASTM A53, Seamless, Grade B, black, no lining. Refer to Section 15061.</td>
</tr>
<tr>
<td>b. Fittings</td>
<td>Steel; ASTM A234: Sch. 40 with plain or beveled ends. Refer to Section 15061.</td>
</tr>
<tr>
<td>c. Corrosion Protection</td>
<td>Polyethylene Sheath; ASTM D1505: high density polyethylene sheath (40 mil) and heat-shrinkable sleeves. Refer to Section 15061.</td>
</tr>
<tr>
<td><strong>5. Electrical Bonding and Grounding:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>As directed by NFPA 54, 3.14.</td>
</tr>
</tbody>
</table>
1. **Test Requirements:**
   a. **Medium:** Clean dry air, CO₂, or Nitrogen.
   b. **Pressure:** 1-1/2 times normal work pressure; not less than 25 psi.
   c. **Duration:** 30 minutes with no indication of leakage.
   d. **Holiday:** All piping below grade shall be electronically tested for defects using a holiday detector (10,000 V. min.)

2. **Joint Requirements:**
   a. Sizes 2” or smaller: Threaded; ANSI B1.20.1: threaded connections with Teflon based pipe joint compound.
   b. Sizes 2-1/2” or larger: Welded; ANSI B31.1: Electrical resistance Butt Welds

3. **Piping Above Grade:**
   a. **Pipe:** Steel Pipe; ASTM A53, Seamless, Grade B, black, no lining. Refer to Section 15061.
   b. **Fittings:** Malleable Steel; ASME B16.3: Malleable iron, black. Refer to Section 15061.
   Steel; ASTM A234: Steel fittings, plain or beveled ends. Refer to Section 15061.

4. **Piping Below Grade:**
   a. **Pipe:** Steel Pipe; ASTM A53, Seamless, Grade B, black, no lining. Refer to Section 15061.
   b. **Fittings:** Malleable Steel; ASME B16.3: Malleable iron, black. Refer to Section 15061.
   Steel; ASTM A234: Steel fittings, plain or beveled ends. Refer to Section 15061.
   c. **Corrosion Protection:** Polyethylene Sheath; ASTM D1505: high density polyethylene sheath (40 mil) and heat-shrinkable sleeves. Refer to Section 15061.

5. **Electrical Bonding and Grounding:** As directed by NFPA 54, 3.14.
Piping Service: Refrigerant Vent

1. Test Requirements:
   a. Medium: Air, refer to specification paragraph 15060-3.06.
   b. Pressure: 150 psig
   c. Duration: 60 minutes

2. Gasket/Joint Requirements:
   a. Flange: Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder.

3. Exposed Pipe and Valves: (See drawings for pipe size)
   a. Pipe: Steel; ASTM A53, ERW, Grade B, black.
      Refer to specification Section 15061.
      Connections shall be butt weld, flanged for relief valves.
      Fitting shall be steel, ASTM A234, seamless, ANSI B16.9, pickled; ends and wall thickness shall match pipe.
      Refer to specification Section 15061.
   b. Valves: N/A

Remarks: Install per the chiller manufacturers’ requirements.
1. **Test Requirements:**
   a. **Medium:** In accordance with Section 723, 2001 CPC.
   b. **Pressure:** In accordance with Section 723, 2001 CPC.
   c. **Duration:** In accordance with Section 723, 2001 CPC.

2. **Joint Requirements:**
   a. **Bell & Spigot:** Rubber Gaskets: ASTM C564: Vulcanized virgin neoprene rubber compound containing no scrap or reclaim products.
   b. **Hubless:**
      - Heavy Duty Couplings: ASTM C 1540 mfg by Husky SD 4000, Clamp all-125 or Cast Iron Couplings with Neoprene Gaskets: ASTM A-48: Cast iron housing with bituminous material coating, ASTM C-564: Circular neoprene gasket with diametrically opposed ears, and 18-8 stainless steel nuts and bolts.

3. **Piping Above Grade:**
   a. **Pipe:** Cast Iron Soil Pipe; ASTM A-888 & CISPI 301, hubless, grey iron castings with smooth interior walls, uniformly coated with suitable adherent material.
      Refer to Section 15062.
   b. **Fittings:** Cast Iron; ASTM A888 & CISPI 301, hubless, grey iron castings conforming to properties and dimensions specified.
      Refer to Section 15062.

4. **Piping Below Grade:**
   a. **Pipe:** Cast Iron Soil Pipe; ASTM A-888 & CISPI 301, hubless, grey iron castings with smooth interior walls, uniformly coated with suitable adherent material.
      Refer to Section 15062.
   b. **Fittings:** Cast Iron; ASTM A888 & CISPI 301, hubless, grey iron castings conforming to properties and dimensions specified.
      Refer to Section 15062.
   c. **Corrosion Protection:** Polyethylene Encasement; AWWA C105: Polyethylene film conforming to ASTM D-1248 and installed per 5-S-4.2.1, Method “A”.
      Refer to Section 15062.
# Piping Service: Storm Drainage System

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Test Requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>a. Medium</td>
<td>In accordance with 2001 CPC.</td>
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<tr>
<td>b. Pressure</td>
<td>In accordance with 2001 CPC.</td>
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<tr>
<td>c. Duration</td>
<td>In accordance with 2001 CPC.</td>
</tr>
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</table>

| **2. Joint Requirements:**   |                                                                               |

| **3. Piping Above Grade:**   |                                                                               |
| a. Pipe                      | Cast iron Soil Pipe; ASTM A-888 & CISPI 301, grey iron casting with smooth interior walls, uniformly coated with suitable adherent material. Refer to Section 15062. |
| b. Fittings                  | Cast Iron; ASTM A888 & CISPI 301: grey iron castings conforming to properties and dimensions specified. Refer to Section 15062. |

| **4. Piping Below Grade:**   |                                                                               |
| a. Pipe                      | Cast Iron Soil Pipe; ASTM A74-R grey iron casting with smooth interior walls, uniformly coated with suitable adherent material. Refer to Section 15062. |
| b. Fittings                  | Cast Iron; ASTM A74: grey iron castings conforming to properties and dimensions specified. Refer to Section 15062. |

END OF SECTION 15060
SECTION 15061 - STEEL PIPE AND FITTINGS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies steel pipe and fittings specified in paragraph 15060-3.8.

1.2 QUALITY ASSURANCE

A. REFERENCES: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ANSI/ASME B16.3 Malleable Iron Threaded Fittings, Class 150 and 300.
- ANSI/ASME B16.11 Forged Steel Fittings, Socket - Welding and Threaded.
- ANSI/ASME B31.1 Power Piping.
- ANSI/ASME B31.9 Building Service Piping.
- ASME B31.2 Fuel Gas Piping.
- ASTM A36 / A36M Structural Steel.
- ASTM A47 Ferritic Malleable Iron Castings.
- ASTM A53 Pipe, Steel, Black and Hot - Dipped, Zinc - Coated Welded and Seamless.
- ASTM A105 / A105M Forgings, Carbon Steel, for Piping Components.
- ASTM A106 Seamless Carbon Steel Pipe for High - Temperature Service.
- ASTM A197 Cupola Malleable Iron.
- ASTM A234 / A234M Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- ASTM A269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- ASTM A283 / A283M Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars.
- ASTM A312 Seamless and Welded Austenitic Stainless Steel Pipes.
- ASTM A450 Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubing.
- ASTM A536 Ductile Iron Castings.
- ASTM A570 / A570M Hot - Rolled Carbon Steel Sheet and Strip, Structural Quality.
- AWWA C200 Steel Water Pipe 6 Inches and Larger.
- AWWA C206 Field Welding of Steel Water Pipe.
- AWWA C207 Steel Pipe Flanges for Waterworks Services-- Sizes 4 In. Through 36 In.
- AWWA C208 Dimensions for Fabricated Steel Water Pipe Fittings.
- ANSI/AWS D1.1 Structural Welding Code.

B. TESTING: Factory testing shall conform to the requirements of ASTM A53, ASTM A106, ASTM A269 or AWWA C200 as applicable.
1.3 SUBMITTALS
   A. Refer to Section 15010 for additional requirements.
   B. The following information shall be provided:
      1. Affidavits of Compliance with AWWA C200, ASTM A53, ASTM A106, ASTM A312, or ASTM A269 as applicable.
      2. Contractor’s piping layout drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturer shall be Bethlehem Steel Company, Kaiser Steel or National Tube Company.

2.2 PIPE MATERIALS
   A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, ASTM A269, ASTM A312, or AWWA C200 as specified in Section 15060, Pipe and Pipe Fittings - General.
   B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.
   C. Steel for pipe fabricated to meet the requirements of ASTM A269 shall conform to the requirements of ASTM A450.
   E. Natural gas piping shall conform to Title 24, Part 5, California Plumbing Code and local utility company requirements.

2.3 PIPE MANUFACTURING
   A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 15060. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10-inch diameter and less. Increased shell thickness shall be provided where specified.
   B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24-inch diameter. Increased shell thickness shall be provided where specified. Unless otherwise specified inside pipe diameter, including lining shall not be less than normal pipe diameter.
2.4 CONNECTIONS

A. Connections shall be as specified in Section 15060 and shall conform to Section 15085. Coating for buried connections shall be as specified in paragraph 15085-2.5. Fabricated steel fittings and appurtenances should be designed in accordance with AWWA M11.

2.5 FITTINGS AND APPURTENANCES

A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.

B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208. Unless otherwise specified, stainless steel fittings and appurtenances shall conform to the requirements of ASTM A269 or ASTM A312.

C. Fittings for grooved end piping systems shall be full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.

D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.6 JOINT GASKETS

A. Joint gaskets shall be as specified in Section 15075.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206 and Section 15085. Sleeve - type mechanical pipe couplings shall be provided in accordance with AWWA M11 and paragraph 15085-2.2-A. Pipe lining and coatings at field joints shall be applied as specified in paragraphs 15061-2.5 and 2.6. Unless otherwise specified, buried mechanical couplings and valves shall be field coated as specified in paragraph 15085-2.5.

B. Anchorage: Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01300.

C. Natural Gas piping system shall be electrically grounded in accordance with NFPA 54, 3.14.

3.2 TESTING

A. Test pressures and allowable leakage shall be as listed in Section 15060.

B. All piping below grade shall be electrically tested for defects using a holiday detector (10,000 U. min.)
C. Natural gas piping with service pressures below 14” shall be tested with clean dry air, CO2, or Nitrogen at 25 psi. Test duration shall be 30 minutes with no indication of leakage.

END OF SECTION 15061
PART 1 - GENERAL

1.1 SCOPE

A. This section specifies pressure and non-pressure applications for copper piping, tubing and fittings.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following standards for manufacturer and installation requirements. They are a part of this section in their entirety or as specifically modified. In case of conflict between the requirements of this section and the following listed documents, the requirements of this Section shall prevail.

- ANSI B16.18 Cast Copper Alloy Solder Joint Pressure Fittings.
- ANSI B16.22 Wrought Copper Alloy Solder Joint Pressure Fittings.
- ANSI B16.23 Cast Copper Alloy Solder Joint Drainage Fittings - DWV
- ANSI B16.26 Cast Copper Alloy Fitting for Flared Copper Tubes
- ANSI B16.29 Wrought Copper and Copper Alloy Solder Joint Drainage Fittings - DWV
- ANSI/ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- ANSI/ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.
- ANSI/AWS A5.8 Brazing Filler Materials
- ASTM B32 Solder Metal.
- ASTM B43 Seamless Red Brass Pipe
- ASTM B88 Seamless Copper Water Tube.
- ASTM B88 Seamless Copper Tube for Oxygen Gas Service, Type K - Hard Drawn Only - in accordance to CDA cleanliness specifications and NFPA 56F, Seamless Copper Tube cleaned for Oxygen Gas Service
- ASTM B280 Streamline Copper Refrigeration Service Tube
- ASTM B306 Streamline Copper Drainage Tube - DWV
- ASTM D1248 Polyethylene Plastics Molding and Extrusion Materials
- ASTM E527 Practice for Numbering Metals and Alloys (UNS)
- AWWA C105/A21.5 Refrigeration Flare-Type Fittings, To SAEJ 513, and Military Standards MS-35867 thru MS-35873 inclusive, MS-35919, and MS-35926.

1.3 SUBMITTALS

A. Refer to Section 15010, 1.10 for additional requirements.

1. Manufacturer’s certificates of compliance with the specified standards.
2. Submittals shall be provided for pipe, pipe fittings, solder material, and polyethylene encasement materials.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer shall be Anaconda, Bridgeport or Meuller.

2.2 SEAMLESS COPPER WATER TUBE

A. Pipe: Seamless copper tube, conforming to ASTM B88. Unless otherwise specified, copper tubing shall be Type L, drawn, where used in exposed service and Type K, annealed or drawn for buried service. Type M grade copper tube shall not be used on this project.


C. Joints:
   1. Brazed connections conforming to ANSI/AWS SA5.8, BCuP series with 15% silver content. Purge interior of tube with minimum Grade B nitrogen as specified in Compressed Gas Association (CGA) G-10.1 or United States Pharmacopeia (USP).
   2. Solder connections conforming to ASTM B32. Solder shall be “Lead Free” with minimum 1% silver content.
   4. Threaded connections shall use PTFE tape or a Teflon based pipe joint compound.

2.3 INDIRECT WASTE

A. Pipe: Seamless copper tube conforming to ASTM B88 or ASTM B306. Piping shall be hard drawn, copper tubing shall be Type L, hard drawn.


C. Joints:
   1. Solder connections conforming to ASTM B32. Solder shall be “Lead Free” with minimum 1% silver content.
   2. Threaded connections shall use PTFE tape or a Teflon based pipe joint compound.

2.4 COPPER DRAINAGE TUBE

A. Pipe: Seamless copper drainage tube conforming to ASTM B306 requirements.

B. Fittings: Wrought copper and copper alloy solder joint drainage fittings conforming with ANSI/ASME B16.29 or cast copper alloy solder joint drainage fittings conforming with ANSI/ASME B16.23.

C. Joints:
   1. Solder connections conforming to ASTM B32. Solder shall be “Lead Free” with minimum 1% silver content.
2. Threaded connections shall use PTFE tape or a Teflon based pipe joint compound.

2.5 SEAMLESS RED BRASS PIPE

A. Pipe: Seamless red brass (Copper Alloy UNS No. C23000) pipe in all nominal pipe sizes conforming to ASTM B43.

B. Fittings: Red brass threaded pipe fittings of nominal pipe size.

C. Joints: Threaded connections shall use PTFE tape or a Teflon based joint compound.

2.6 POLYETHYLENE FILM ENCASEMENT

A. Film: ASTM D1248, polyethylene film in tube form, manufactured of virgin polyethylene material.

B. Physical Properties:

1. Tensile strength: 1,200 psi minimum.
2. Elongation: 300% of minimum.
3. Dielectric Strength: 300 V/mil thickness minimum.
4. Thickness: 8 mil, +/- 10% tolerance.
5. Size: Per table 5-1, AWWA C105.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Confirm excavations and natural soil compaction has been completed per general requirements.

B. Confirm excavations are to required grade and are not over-excavated.

C. Confirm trench walls are properly shored to comply with OSHA requirements prior to workmen entering the trench.

3.2 PREPARATION

A. Provide sand bedding at trench bottom to comply with general requirements.

B. Repair any piping or utilities damaged during excavation. Insure utility service is fully operational following repairs.

3.3 INSTALLATION

A. Install piping to comply with IAPMO installation standards and 2001 California Plumbing Code requirements.
B. Align piping properly in a straight and direct fashion. Maintain uniform gradient throughout drainage systems.

C. Remove dirt and debris inside and outside piping prior to assembly.

D. Provide polyethylene tube encasement for all underground piping to comply with AWWA C105, Method “B” requirements.

E. Provide pipe supports and seismic bracing within the building as specified in Sections 15140 and 15141.

F. Provide PTFE tape or Teflon based pipe joint compound on male thread of all threaded pipe connections.

G. Takedown Couplings: Takedown couplings shall be screw union type and shall be provided in accordance with Section 15085.

H. Dielectric Protection: Copper tubing or fittings shall not be permitted to come in contact with steel piping, reinforcing steel, or any other contact made between copper tubing and steel elements. Whenever electrical contact is demonstrated by such test, the Contractor shall provide dielectric protection as specified in Section 15085.

I. Install piping to conserve building space and not interfere with use of space.

J. Group piping whenever practical at common elevations.

K. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

L. Provide clearance for installation and access to valves and fittings.

M. Establish elevations of buried piping outside the building to ensure not less than 18 inches of cover.

N. Red brass pipe nipples shall be used in conjunction with copper piping. Steel pipe nipples shall not be used without dielectric fittings as specified in Section 15085.

O. Remove excess soldering flux from pipe exterior. Flush excess flux from pipe interior.

P. Copper fitting solder cups and copper piping ends for sizes 2-1/2” and larger shall be “tinned” prior to assembly for soldering process. Solder used for tinning shall be the same grade and type of the solder used for final connection.

Q. Bronze pipe flanges (ANSI/ASME B16.24) shall not be silver soldered or brazed. Bronze flanges shall be soldered in compliance with ASTM B32 using a “Lead Free” solder.

3.4 APPLICATION

A. Install unions or flanges downstream of valves and at equipment or apparatus connections.

B. Provide polyethylene encasement for all piping below grade. Provide 10 mil polyethylene pipe wrap tape, 2” wide, to secure wrapping.

END OF SECTION 15066

COPPER PIPE AND FITTINGS
15066 - 4
PART 1 - GENERAL

1.1 SCOPE

A. This section specifies fiberglass reinforced plastic (FRP) pipe and fittings.

1.2 QUALITY ASSURANCE

A. REFERENCES: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM C177 Thermal Transmission Properties.
- ASTM D570 Water Absorption of Plastics.
- ASTM D635 Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.
- ASTM D638 Tensile Properties of Plastics.
- ASTM D695 Compressive Properties of Rigid Plastics.
- ASTM D696 Coefficient of Linear Thermal Expansion of Plastics.
- ASTM D792 Specific Gravity (Relative Density) and Density of Plastics by Displacement.
- ASTM D1599 Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings.
- ASTM D2105 Longitudinal Tensile Properties of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube.
- ASTM D2143 Cyclic Pressure Strength of Reinforced, Thermosetting Plastic Pipe.
- ASTM D2290 Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method.
- ASTM D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
- ASTM D2992 Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings.
- ASTM D2996 Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
- ASTM D3517 “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe.
- ASTM D3567 Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings.
- ASTM D3681 Chemical Resistance of Reinforced Thermosetting Resin Pipe in a Deflected Condition.
- ASTM D3839 Underground Installation of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
- ASTM D4024 Reinforced Thermosetting Resin Flanges.
- AWWA C950 Fiberglass Pressure Pipe.
B. The fiberglass pipe and fitting manufacturer’s quality systems shall be in compliance with one of the following:

1. ISO 9001
2. API Q1.

C. To insure these quality standards, all fiberglass pipe and fittings shall be manufactured by a single manufacturer.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Provide:

1. Manufacturer’s certificates of compliance with the specified standards.
2. Contractor’s layout drawings and shop fabrication drawings. Shop drawings shall include piping supports and their configuration.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer shall be Smith Fibercast Model Green Thread, Ameron “Bondstrand” Fiberglass Pipe Division or equal.

2.2 PIPE AND FITTING DESIGN REQUIREMENTS

A. Cell Classification:

1. Method of construction shall be filament wound (Type I).
2. Construction and materials shall be glass-fiber-reinforced epoxy resin (Grade 1)

B. Materials:

1. The resins, reinforcement, colorants, fillers, and other materials, when combined as a composite structure, shall produce pipe products that meet the performance requirements of the latest version of AWWA C950, Sec 4.1.
2. Gaskets and lubricants shall be made from materials that (1) are compatible with the plastic materials and with each other when used together, (2) will not support the growth of bacteria, and (3) will not be adversely affected from exposure to ozone.
3. Ultraviolet Radiation Protection (ASTM G53):
   a. Exposed piping subject to ultraviolet radiation (UV) shall be furnished with a 0.040 inch overwrap of organic veil tape.
   b. Piping may also be furnished with an exterior resin with an ultraviolet inhibitor in lieu of the organic veil tape overwrap will be consider acceptable.
C. Pipe Dimensions:

1. Pipe diameters and tolerances shall be measured in accordance with ASTM D3567. Pipe dimensions shall conform to Tables 1-6 as listed in AWWA C950.
2. Pipe shall be furnished in standard laying lengths as agreed on by the purchaser and manufacturer. A maximum of 15 percent of the footage of each pipe size may be furnished in random lengths. Each random length furnished shall not vary by more than 25 percent from the standard laying length specified, except for special orders.
3. The average wall thickness of the pipe shall not be less than the nominal wall thickness indicated by the manufacturer. The minimum wall thickness at any point shall not be less than 87.5 percent of that nominal wall thickness when measured in accordance with ASTM D3567.

D. Pressure Classes:

1. The maximum sustained working pressure shall be determined by the long-term hydrostatic design pressure using a design factor of 1.8.
   a. The long-term hydrostatic design pressure shall be based on data extrapolated to 50 years, using procedure B of ASTM D2992, ASTM D3517, Annex A.
   b. The precision and bias for obtaining the cyclic hydrostatic design basis (HDB) shall be obtained as specified in ASTM D2143 or as specified in AWWA C950 for “custom” producers.

E. Stiffness Classes:

1. The minimum pipe stiffness shall be determined at 5 percent deflection using the apparatus and procedure as specified in ASTM D2412.

F. Long-Term Ring-Bending Strength:

1. The long-term ring-bending strength by the following methods:
   a. Test as described in AWWA C950, Section 4.8.
   b. In accordance with ASTM D3681, using 1N of sulfuric acid.
   c. Using results of ASTM D2992, method B.

G. Joint Types and Requirements:

1. Joints shall meet the performance requirements of ASTM D4161, Sec. 7. Restrained rigid joints shall be exempt from angular-deflection requirements.
2. Adhesive-bonded joints: Each type of joint shall meet or exceed the hoop tensile and axial tensile strength requirements of the pipe. The permissible types of joints are as follows:
   a. Tapered bell and spigot.
   b. Straight bell and spigot.
   c. Tapered bell and straight spigot.
3. Reinforced-overlay joint:
   a. The tensile and shear strength of the overlay shall be equal to or greater than the minimum axial tensile strength of the pipe as determined by the average test results of ASTM D2105 or ASTM D638.
4. Gasketed bell-and-spigot or coupling joint:
   a. The pipe may have gasketed bell-and-spigot or coupling joints.
   b. These joints shall be longitudinally restrained by one of three methods outlined in AWWA C950, 2.7.3.1.

5. Mechanical joint:
   a. Joints may be flanged, threaded, compression couplings, or commercially available proprietary joints.
   b. All mechanical joints shall be capable of conveying water at the pressure and temperature allowed for the pipe class with which they are to be used.

H. Quality Control Requirements: The pipe and fittings shall meet all the requirements as specified in AWWA C950, Sec. 3. The minimum elastic and strength properties of filament wound pipe shall be as follows:

1. Hoop Tensile Strength (Based on loading of pipe hydrostatically), ASTM D1599, ASTM D2290, & ASTM D638:
   a. Ultimate (porosity) 20,000 psig
   b. Yield 12,800 psig.
   c. Allowable 6,700 psig.
   d. Modulus of Elasticity 3.6 x 10^6 psig.

2. Tensile (Based on loading of pipe as tension member), ASTM D2105:
   a. Ultimate (rupture) 8,000 psig.
   b. Yield 15,000 psig.
   c. Allowable 6,300 psig.
   d. Modulus of Elasticity 1.8 x 10^6 psig.

3. Thermal Properties, ASTM C177, ASTM D696:
   a. Coefficient of Thermal Expansion 8.5 x 10 In/In/°F.
   b. Thermal Conductivity 2.3 BTU/Hr. Ft. °F/M.

4. Flexural (Based on loading of pipe as beam), ASTM D2925:
   a. Ultimate (rupture) 15,700 psig.
   b. Yield 6,100 psig.
   c. Allowable 4,000 psig.
   d. Modulus of Elasticity 1.7 x 10^6 psig.

5. Torsion (Based on loading of pipe as a shaft in torsion):
   a. Ultimate Shear (rupture) 16,200 psig.
   b. Allowable Shear 5,500 psig.
   c. Shear Modulus 0.75 x 10^6 psig.

6. Compression (Based on loading of pipe as a “short compression member”), ASTM D695, ASTM D2412:
   a. Ultimate (rupture) 11,200 psig.
b. Yield 7,000 psig.
c. Allowable 3,700 psig.
d. Modulus of Elasticity 1.4 x 10^6 psig.

7. Minimum Safety Factors for Fittings:

c. Yield 1.5:1.

8. Specific Gravity (ASTM D792) 1.81.
11. Absolute Roughness 50 x 10^-6 / ft.
12. Water Absorption (ASTM D570) 0.15 max %.

PART 3 - EXECUTION

3.1 PREPARATION

A. Training and Certification: All joints installed or constructed in the field shall be assembled by employees of the Contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor’s employees in the proper joining and assembly procedures required for the project, including hands-on training by the contractor’s employees.

B. All piping materials shall be inspected upon delivery for fractures, chips, or any other defects. Verify material delivered is the material specified and reviewed.

3.2 INSTALLATION

A. All pipes above ground shall use flange connections (ASTM D4024).

B. Pipe shall be installed in compliance with ASTM D3839.

C. Pipe shall be installed in accordance with the manufacturer’s current published installation procedures.

D. Piping shall be shop fabricated wherever possible and practical.

E. All fabricated tee weld or insert fitting shall be shop fabricated to comply with PS-1569 requirements. Continuous filament windings over butt wrapped joints.

3.3 ACCEPTANCE TESTING

A. Provide cyclic pressure test shall be conducted on the completed system. The pipe system shall be subjected to 10 pressurization cycles at the pressure indicated in Section 15060. Pressure shall then be held on the system for 2 hours and the line inspected for leaks.

B. Test pressure shall not exceed 1-1/2 times the maximum rated operating pressure of the lowest rated element in the system.
C. The system shall be filled with water at the lowest point and air bled off from the highest point. Systems shall be brought up to test pressure slowly to prevent water hammer or over-pressurization.

END OF SECTION 15068
SECTION 15070 - PREFABRICATED UNDERGROUND PIPING

PART 1 - GENERAL

1.1 SCOPE

A. Scope: This section specifies pre-insulated liquid piping for direct burial installation. This section does not provide specifications for insulation for piping installed in rooms, pipe chases, or exposed to view. Fluid temperatures are limited to the range 40°F to 210°F.

B. Type:

1. Carrier pipe for chilled water shall be polyvinyl chloride (PVC).
2. Insulation shall be of the factory-applied urethane foam; jacket shall be a seamless high density polyethylene (HDPE). FRP jacketing will not be allowed.
3. Fittings for chilled water shall be ductile iron.
4. All joints shall be supported via restraining joints. Mechanical joints and fittings as specified in paragraph 2.2E shall be provided by the contractor.

C. Performance and Service Requirements: Insulated piping furnished under this specification shall be suitable for direct burial or installation in pipe trenches. Fluid temperatures and pressures shall be as listed in Section 15060. Ground temperatures will range from 50°F to 70°F, and the piping may be installed below the water table.

D. Chilled Water System

<table>
<thead>
<tr>
<th>Nominal in Inches</th>
<th>Jacket in Inches</th>
<th>Insulation in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>15</td>
<td>2.1”</td>
</tr>
</tbody>
</table>

E. A plus/minus 15% tolerance, on the insulation thickness listed above shall be permitted for manufacturers’ standard insulation systems.

F. Piping Systems: The following piping systems, as defined in Section 15060, shall be insulated in accordance with this section:

CHWS / CHWR Buried Chilled Water Supply and Return

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

ANSI/ASTM D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

PREFABRICATED UNDERGROUND PIPING

15070 - 1
B. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

C. Supply all equipment and accessories new and free from defects.

D. Supply all equipment and accessories in compliance with the applicable standards listed in this section and with all applicable national and state codes.

E. All pre-insulated pipe shall be the product of the same manufacturer.

F. Certification:

1. Detailed literature that notes compliance with reference standards. Include type, pressure rating, schedule, class and grade.

G. Manufacturer’s Responsibility:

1. A qualified, direct factory employed technician of underground insulated piping manufacturer, shall provide Field Technical Assistance (FTA), minimum one day, during all critical periods of installation and pressure tests. Technician shall witness and sign all pressure tests. Manufacturer’s technician shall also be on-site for one day of training on installation procedures for Contractor.

2. Furnish certificate upon completion of installation indicating that system was installed in accordance with manufacturer’s recommendations.
3. One (1) day of FTA shall be provided for 500 feet of pipe trench. The FTA representative shall observe critical periods of the installation including the following.

   a. Inspection of the first load of material during unloading.
   b. Initial inspection of the trench and initial pipe placement.
   c. Initial field joint closure instruction and inspection.
   d. Any field modification to the piping system.
   e. Initial backfill of piping in trench.
   f. Include a report consisting of the installation log indicating actual installed conditions and test certification signed by the manufacturer’s representative above, the contractor, and the Owner’s representative. Include certification by the manufacturer’s representative that the installation is in conformance with the manufacturer’s recommendations.
   g. Furnish certificate upon completion of installation indicating that system was installed in accordance with manufacturer’s recommendations. Factory trained core pipe and insulation representative costs shall be included in the base bid for a period of 3 days during start-up; a per diem rate shall also be provided for any time period on site for additional time deemed beneficial.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

1. A complete description of the preinsulated piping and accessories in sufficient detail to demonstrate compliance with each item in this specification.
2. Manufacturer’s certification in accordance with this section.
3. Certification that the jacket meets the requirement of this section.
4. Manufacturer’s recommended field installation instructions including pipe jointing techniques, joint insulation, and jacket sealing.
5. A copy of this specification section with addenda updates, and all referenced sections with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

1.4 GUARANTEE

A. Upon completion of work, submit to a written guarantee in accordance with Section 15010 guaranteeing installed piping to be free from any and all defects in workmanship and/or material for period of five years from date of final acceptance of system by the Owner.

PART 2 - PRODUCTS

2.1 CHILLED WATER PIPING

A. Manufacturer shall be Thermacor, Rovanco, Perma-Pipe or equal.
2.2 MATERIALS

A. Carrier Pipe:

1. Unless otherwise specified, carrier pipe materials shall be as specified in Section 15060, for each piping system. Carrier pipe for chilled water shall be polyvinyl chloride (PVC).
2. Straight sections shall be supplied in twenty-foot lengths with six inches of piping exposed at each end for field joint fabrication.
3. Fittings for chilled water shall be ductile iron.
4. All joints shall be gasketed. All joints shall be supported via restraining joints. Mechanical joints and fittings as specified in paragraph 2.2F shall be provided by the contractor.

B. Urethane Foam Insulation:

1. Closed cell content shall be 90-95% in conformance to MIL-I-24172.
2. “K” value: ASTM C518; 0.13 at 75°F.
3. Density: 2 lbs/cu. ft

C. Insulation:

1. All PVC shall conform to ASTM D1784, Class 12959-B.
2. The outer protective jacket shall be high density polyethylene (HDPE) with polyurethane foam insulation. Polyurethane foam insulation shall be poured or injected and shall be guaranteed 100% Void Free by the Underground Piping System Manufacturer.
3. Insulation shall be a nominal 2 pounds per cubic foot density, polyurethane foam applied to a nominal thickness of 2”. All urethane foam shall meet ASTM C 591 and have the minimum characteristics of 0.14 to 0.17 K-factor, density of 2 pounds per cubic foot (pcf) and a closed cell content of 90 to 95%.
4. All straights shall be factory pre-insulated and jacketed. No tape, FRP wrap or filament wound jackets will be allowed.
5. Ends of all factory insulated pipe will be sealed at the factory with polyethylene heat shrink end seals.
6. All field cuts will be sealed with polyethylene heat shrink end seals supplied by the pre-insulated piping supplier.

D. Fittings shall be uninsulated mechanical joint type as specified in 2.02-F. Field joints should utilize push-joint piping and be restrained only where deemed applicable for system integrity. Quality assurance procedures for the insulation shall be engineer approved equal check method of the entire length to ensure there are no insulation voids. X-ray test reports, on each length of pipe and fitting shall be forwarded to the Contractor and Owner’s Representative with each shipment.

E. Restraining joints provided by the contractor shall be EBAA Iron or equal.

1. Restrainment joints shall be provided for all fittings for this project.
2. Restraining joints between all pre-insulated PVC pipes and ductile iron fittings shall be EBAA Iron Series 2000 or equal (no known equal). The mechanical joint restraint shall be incorporated into the design of the follower gland. The restraint mechanism shall consist of a plurality of individually actuated gripping surfaces to maximize restraint capability. Glands shall be manufactured of ductile iron conforming to ASTM A532-80. The gland shall be such that it can replace the standardized mechanical joint gland and can be used with the standardized mechanical joint bell conforming to ANSI/AWWA C111/A21.11 and ANSI/AWWA C153/A21.53 of latest revision. Twist off nuts, sized same as tee-head bolts, and shall be used to insure proper actuating of restraining devices. The restraining glands shall have a pressure rating equal to that of the pipe.
on which it is used. The restraining glands shall have been tested to UNI-B-13-92, be listed by UL and be approved by Factory Mutual.

F. Shrinkable Sleeves: Shrinkable sleeves for field joints shall be compatible with the PVC or PE jacket. Shrinkable sleeves shall be fabricated from radiation cross-linked semi-rigid polyethylene, coated on all inside surfaces with thixotropic adhesive designed to flow and provide a complete seal when heated.

2.3 MANUFACTURING

A. General: Pipe sections shall be prefabricated in such a way that the urethane completely fills the annular space between the carrier pipe and the PVC or PE jacket. The exposed insulation at the end of each section shall be sealed with a factory-applied, watertight sealant. The carrier pipe shall extend a minimum of 6 inches beyond the insulation.

B. End Seals:

1. Each length of pre-insulated pipe will be fitted with a watertight end seal at jacket and pipe surfaces. All field cuts will be sealed with a field applied end seal. The end seals shall be as follows.

2. Casing and End Seal Testing Certification: Test and certification procedures shall demonstrate that casing, factory and field applied end seal are capable of resisting penetration of water into the casing and insulation at 20 feet of head pressure, measured above the highest point of the test sample, subjected over the entire surface of an 8 foot casing test sample for not less than 48 hours.

PART 3 - EXECUTION

3.1 GENERAL:

A. Unloading, handling and installation of underground insulated piping system to be in strict accordance with manufacturer’s recommendations.

3.2 FIELD TESTING:

A. Prior to insulating any field joints, individual pipe sections shall be hydrostatically tested at the test pressure and temperature indicated in Section 15060. The Owner shall be notified in writing 48 hours prior to testing. Any leaks shall be repaired, and the system shall be retested until no leaks are detected by the Owner.

3.3 FACTORY REPRESENTATIVE:

A. A qualified factory representative of the piping system manufacturer shall be present during the initiation of the buried piping installation and as indicated in paragraph 1.2 G.

END OF SECTION 15070

PREFABRICATED UNDERGROUND PIPING

15070 - 5
SECTION 15101 - GATE VALVES

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies bronze body gate valves, corrosion resistant gate valves, and iron body gate valves.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM A47-90 Ferritic Malleable Iron Castings.
- ASTM B61-93 Steam or Valve Bronze Castings.
- ASTM B62-93 Composition Bronze or Ounce Metal Castings.
- ASTM A197-87 Cupola Malleable Iron.
- ASTM A276-91 Stainless and Heat-Resisting Steel Bars and Shapes.
- ASTM A395-88 Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
- ANSI/AWWA C500-86 Gate Valves for Water and Sewerage Systems.
- FS-WWV-54D-73 Bronze Gate Valves.
- FS-WWV-58b-71 Cast Iron Gate Valves

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Product Data: Manufacturer’s catalog information including dimensions cross-sectional views, details of construction and materials list shall be provided per Section 15010.

PART 2 - PRODUCTS

2.1 BRONZE BODY VALVES

A. Manufacturers shall be Nibco T-154-A, Stockham Valve, Crane or equal.

B. MSS-SP80, bronze body and solid disc (ASTM B61) with stainless steel seat ring (ASTM A167). Rising stem with malleable iron hand wheel (ASTM A47). Provide with union bonnet and IPS threaded end connections. Packing material shall be a non-asbestos material suitable for service temperature and pressure.

C. Rating: 200 lb. S.W.P.; 400 lb. W.O.G.
2.2 CORROSION RESISTANT VALVES

A. Manufacturer shall be Asahi/America Model 50(6) or equal.

B. Gate valves shall be constructed of Type 1, Grade 1, PVC and shall have a stainless steel stem. The “gate” shall be of a tapered cylindrical plug design made of PVC, thickly lined with a styrene butadiene rubber (SBR) material. Valve shall have shallow seating area in bottom of valve body, be self-cleaning and be of the rising stem design. Piping connections shall be 150 lb.flanged.

C. Rating: 150 lb.-C.W.P.

D. Options: Provide Viton O-rings and seals.

2.3 IRON BODY VALVES

A. Manufacturers shall be Nibco, Hammond, Kennedy or equal.

B. Below Grade Service:

1. MSS SP70, ANSI/AWWA C509, ANSI/AWWA C550, valve with cast iron body (ASTM A126) and non-rising bronze alloy stem.
2. Provide with ductile iron (ASTM A536) solid disc vulcanized with SBR rubber compound.
3. Valve trim shall be bronze alloy.
4. Provide with 2” square cast iron (ASTM A126) or bronze alloy operating nut.
5. Packing and gaskets shall be non-asbestos materials approved for the particular service.
6. Provide valve with fusion bonded epoxy resin inside and outside.

C. Above Grade Service:

1. MSS SP70, ANSI/AWWA C500, 3% nickel cast iron (ASTM A126) body, outside stem and yoke (OS&Y) valve with stainless steel stem, seat ring, and solid 3% nickel cast iron disc.
2. The backseat bushing shall be 410 stainless steel.
3. Valve trim shall be stainless steel.
4. Handwheel shall be malleable iron (ASTM A-197) or ductile iron (ASTM A395).
5. Packings shall be non-asbestos materials approved for the particular service.

D. Rating: Unless otherwise specified, valves, as a minimum, shall conform to the following pressure ratings:

1. 2 through 12 inches: 200 psig design pressure, 300 psig hydrostatic test pressure.

2.4 VALVE ACCESSORIES

A. Valve Extension Boxes

1. Manufacturer shall be Alhambra Foundry Model No. A-3000 or equal.
2. Extension boxes shall be cast iron sized according to valve size and depth of trench. They shall be furnished with screw adjustment and covers designating “Water” unless otherwise stated.
PART 3 - EXECUTION

3.1 APPLICATION

A. Bronze body valves shall be used for all water services 3” or smaller with the exception of valves used in sewage systems.

B. Iron body gate valves shall be used for all sewerage systems and water services 4” or larger. Iron body gate valves located below grade shall be provided with a fusion bonded epoxy resin inside and outside in compliance with ANSI/AWWA C550 requirements.

C. Valve Extension Boxes shall be provided for all valves below grade which are not in an accessible vault. Valve extension boxes shall be installed vertically and extended to finish grade flush with surrounding grade.

D. Corrosion resistant gate valves shall be used for water services located in corrosive areas above grade such as the cooling tower area.

3.2 INSTALLATION

A. All valves shall be mounted with their valve stems above centerline of the pipe service.

B. All valves used in sewage systems shall be iron body and comply with the requirements of ANSI/AWWA C509 and ANSI/AWWA C550.

C. Valves shall be located to allow clearances for repair and replacement.

D. Gate valves shall not be used on pneumatic services unless specified otherwise.

E. Flush service lines with water prior to valve placement when practical and possible.

F. Gate valves shall not be used for throttling purposes. Valves, when in service, shall be maintained in a fully open or fully closed position.

END OF SECTION 15101
PART 1 - GENERAL

1.1 SCOPE

A. This section specifies ball valves.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM A6 General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use.
- ASTM A276 Stainless and Heat-Resisting Steel Bars and Shapes.
- ASTM A351 Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts.
- ASTM A439 Austenitic Ductile Iron Castings.
- ASTM A449 Quenched and Tempered Steel Bolts and Studs.
- ASTM B584 Copper Alloy Sand Castings for General Use.
- ANSI/AWWA C507 Ball valves, 6 In. through 48 In.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Product Data: Manufacturer’s catalog information including dimensions cross-sectional views, details of construction and materials list shall be provided.

PART 2 - PRODUCTS

2.1 BRONZE BODY VALVES

A. Manufacturers shall be Nibco Model T-585-70-66, Watts or equal.

B. MSS-SP110, bronze, two piece body (ASTM B584 or ASTM B52) valve with stainless steel full-port ball and stem (ASTM A276). Furnish with Teflon packings and ball seats and fluorocarbon rubber O-ring seals. Body nuts and bolts shall be zinc dichromate plated steel (ASTM A449). Valve may be furnished with threaded or solder end connections. Insulated valves shall have Nibco NIB-SEAL or equal insulated extended handle and shall include a vapor seal, adjustable memory stop and valve packing maintenance without disturbing the insulation.

C. MSS-SP110, bronze body valve for compressed dry air service shall be bronze, three-piece body (ASTM B584 or ASTM B52) valve with stainless steel full-port ball and stem (ASTM A276). Furnish with...
Teflon packings and ball seats and fluorocarbon rubber O-ring seals. Body nuts and bolts shall be zinc dichromate plated steel (ASTM A449). Valves shall be cleaned and bagged for oxygen service by the manufacturer in accordance with CGA pamphlet G-4.1.

D. Rating: 150 lb.-S.W.P., 600 lb.-W.O.G.

2.2 IRON BODY VALVES

A. Manufacturers shall be Watts Regulator G4000, Nibco, Tyco, or equal.

B. MSS-SP110, & ANSI/AWWA C507, full-port, quarter turn, iron body or steel body valve with gray iron packing gland (ASTM A126). Stem, ball, and stop washer shall be 304 stainless steel (ASTM A351). The handle shall be ductile iron (ASTM A439). Provide valve with Teflon gasket, packing, and seats. Stop plate, nuts, and bolts shall be steel (ASTM A6). Valve end connections shall comply with ANSI 16.1 requirements for 125 lb. flanges.

C. Rating: 200 lb.-C.W.P.

PART 3 - EXECUTION

3.1 APPLICATION

A. Bronze body ball valves shall be used for water services sizes 2-1/2” and smaller.

B. Iron body ball valves shall be used for water services 3” and larger.

3.2 INSTALLATION

A. Valves shall be located to allow for clearances for repair and replacement.

B. Flush service lines with water prior to valve placement when practical and possible.

C. Dismantle three piece ball valves prior to brazing or silver soldering end connectors.

END OF SECTION 15102
SECTION 15103 - BUTTERFLY VALVES

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies high performance butterfly valves for water service.

B. Types:

1. Type A: Valves used in the chilled or cold water piping systems shall be designated Type A.
2. Type B: Valves used in the condenser water piping systems shall be designated Type B.
3. Type C: Valves installed below grade for water piping systems shall be designated Type C.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ANSI/ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800.
- ANSI B 16.34 Valves-Flanged and Buttwelding ends.
- MSS-SP-25 Standard marking system for valves, fittings, flanges and unions
- MSS-SP-61 Pressure testing of steel valves.
- MSS-SP-68 High pressure-offset seat Butterfly valves
- API-609 Butterfly valves-lug and wafer type
- ASTM A108 Steel Bars, Carbon, Cold - Finished, Standard Quality.
- ASTM A276 Stainless and Heat - Resisting Steel Bars and Shapes.
- ASTM A436 Austenitic Gray Iron Castings.
- ASTM A536 Ductile Iron Castings.
- AWWA C504 Rubber - Seated Butterfly Valves.

1.3 SUBMITTALS

A. Product Data:

1. Affidavits of compliance to ANSI, MSS-SP, API for Type A and B valves.
2. AWWA C504 for Type C valves.

B. Product data on valve materials shall be provided in accordance with Section 15010:

1. All components and their dimensional data.
2. Surface finish guarantees.
3. Leakage rates.
4. Flow versus pressure drop and/or flow coefficient (Cv) data.
5. Detailed description of cleaning procedures.
1.4 COORDINATION

A. When more than one piping system material is joined to a valve, ensure systems components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.

B. Use unions, flanges, and downstream valves for equipment or apparatus connections. Use dielectric unions where joining dissimilar materials. Do not use direct welded or threaded connections.

C. Use butterfly for shut-off and to isolate equipment, part of systems, or vertical risers.

D. Use butterfly valves for throttling, bypass or manual flow control services.

E. End preparation and bore of valves shall match equipment connections and piping for various services specified.

F. Ensure components are indicated on the drawings and in piping schematics.

G. Butterfly valves shall be furnished with gear operator if 6 inches and larger and, if located aboveground, clearly visible position indicator with stops for open and closed positions.

PART 2 - PRODUCTS

2.1 TYPE A VALVES

A. Manufacturer of high performance butterfly valves shall be Nibco High Performance Valves, Tyco-Keystone, Flowseal or Jamesbury.

B. Valve shall:
   1. Comply with requirements of MSS SP-68 High Pressure Butterfly Valves with Offset Design.
   2. Full lug style suitable for bi-directional end of line service at full rated pressure.
   3. ANSI Class 150 with carbon steel body (ASTM- B16.34) and 316 stainless steel disc (ASTM-A182 F 316 or A 351 GR CF8M), and stainless steel shaft 17-4 PH (ASTM- A 564 TYPE 630 H 1150).
   4. Provide PTFE packing and seat for sealing surface.
   5. Provide with field replaceable seats.

C. Unless otherwise specified, valves, as a minimum, shall conform to the following pressure ratings:
   1. 2 through 12 inches; 285 psig design pressure, 428 psig hydrostatic test pressure.
   2. 2 through 24 inches: 150 psig “dead end” service pressure.

D. Manual valve operators refer to Section 15185.

2.2 TYPE B VALVES

A. Manufacturer of high performance butterfly valves shall be Nibco High Performance Valves, Tyco-Keystone, Flowseal or Jamesbury.

B. MSS-SP68, full lug style valve with carbon steel body (ASTM- B16.34) or ductile iron body (ASTM A-395), 316 stainless steel disc (ASTM- A182 F 316 or A 351 GR CF8M), or aluminum/bronze disc (ASTM A-276 or ASTM B 148 C 958), and stainless steel shaft 17-4 PH (ASTM- A 564 TYPE 630 H
1150). Provide PTFE packing and seat for sealing surface. Provide all valves with field replaceable seats. Units shall be bubble tight, ANSI Class 150# with blow-out proof shaft.

C. Unless otherwise specified, valves, as a minimum, shall conform to the following pressure ratings:

1. 2 through 12 inches; 285 psig design pressure, 428 psig hydrostatic test pressure.
2. 2 through 24 inches: 150 psig “dead end” service pressure.

D. Valve body shall have an epoxy coating or stainless steel body for applications at or near the cooling towers.

E. Manual valve operators refer to Section 15185.

2.3 TYPE C VALVES

A. Manufacturer of high performance butterfly valves shall be Nibco High Performance Valves, Tyco-Keystone, Flowseal or Jamesbury.

B. ANSI/AWWA C504, ductile iron body with two integral shaft-bearing hubs, flanges to conform to ANSI/AWWA C110/A21.10, stainless steel or nickel/copper alloy stub shaft, ductile iron disc, with rubber disc seat and stainless steel reinforcing ring. Shaft seals shall be of a design to allow replacement without removing the valve shaft. Interior and exterior surfaces shall be coated to conform to FS TT-C-494B requirements.

C. Unless otherwise specified, valves, as a minimum, shall conform to the following pressure ratings:

1. 3 through 12 inches; 150 psig design pressure, 225 psig hydrostatic test pressure.
2. 3 through 24 inches: 150 psig “dead end” service pressure.

D. Manual Valve Operators:

1. Shall be of the traveling nut or rack and pinion type. Manual operators shall be designed in accordance with AWWA C504 and shall have a disc position indicator visible from the ground designating the opened and closed position of the valve.
2. Operators shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the disc in the open and closed positions and shall be self-locking and designed to hold the valve in any intermediate position between full open and full closed. Valve operator components shall withstand an input torque of 300 ft-lbs. at the extreme operator positions without damage.
3. Operator for buried service shall include an AWWA operating nut and shall be gasketed and grease packed for submerged operation at water pressure to 10 psig.
4. Operators for exposed service shall include a hand wheel and be designed for weatherproof service.
PART 3 - EXECUTION

3.1 EXECUTION

A. Valves in this section shall be installed in accordance with the manufacturer’s recommendations as outlined in their installation, operation, and maintenance manual.

END OF SECTION 15103
SECTION 15108 - CHECK VALVES

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies check valves.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM A269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
- ASTM A536 Ductile Iron Castings.
- ASTM A582 Free-Machining Stainless and Heat-Resistant Steel Bars, Hot-Rolled or Cold-Finished.
- ASTM B16 Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines.
- ASTM B61 Steam or Valve Bronze Castings.
- ASTM B62 Composition Bronze or Ounce Metal Castings.
- ASTM B150 Aluminum Bronze Rod, Bar, and Shapes.
- ASTM B271 Copper-Base Alloy Centrifugal Castings.
- ASTM B584 Copper Alloy Sand Castings for General Applications.
- AWWA C508 Swing-Check Valves for Waterworks Service, 2 inches through 24 inches NPS.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Product Data: Provide manufacturer’s catalog information including dimensions cross-sectional views, details of construction and materials list.

PART 2 - PRODUCTS

2.1 SWING CHECK VALVES

A. Manufacturer shall be Nibco, Muller, Hammond, Stockham or equal.

B. Bronze body (ASTM B62) with IPS threaded ends, re-grindable or replaceable bronze seat, threaded bonnet, bronze disc, and stainless steel hinge pin.

C. Rating: 200 lb.-S.W.P.; 400 lb.-W.O.G.
2.2 GLOBE STYLE, SILENT CHECK VALVES

A. Manufacturer shall be APCO Series 600, Val-Matic or equal.

B. Globe style, silent check valve shall be provided with a cast iron body (ASTM A126) and rated for service of 200 WOG (2” – 12”), 150 WOG (14” and larger). Valve shall have a minimum open area in the body of 110% of the area of the entering or corresponding pipe size. Provide with 125# ANSI flat face flange, 302 SS helical spring, bronze disc, dual guided (top and bottom) with a Buna-N seat. Valve shall comply with API 598. Unit shall operate silently in either vertical or horizontal position. Valve body shall extend on the discharge side to allow for the direct amount of a butterfly valve. Valve shall be Factory Mutual Approved.

2.3 NON-SLAM SPRING LOADED CHECK VALVE

A. Manufacturer shall be Mueller Steam Specialty Fig. No. 71AHB-3-H, Tyco/Gulf Valve or equal.

B. Check valves shall be:

1. Non-slam spring loaded type and the same size as the entering pipe.
2. Wafer style and have a pressure and temperature rating equal to or greater than the pipeline in which they are installed.
3. Check valves 2 thru 12 inches shall be rated 200 PSI WOG, have a cast iron body (ASTM A-126, Gr. B) to fit inside 125# ANSI bolt circles, a double Bronze disc (ASTM B-62, 85-5-5-5) type 316 stainless steel dual shafts, type 316 Stainless Steel torsion spring and have an integrally molded Buna-N seat vulcanized to the body.
4. Valve for horizontal flow shall be installed with the shafts in vertical position.
5. Valve is to operate silently and provide a seal, which meets or exceeds API Standard 598, 3.7.2.
6. A flanged spool piece shall be installed where required to provide operating clearance between hinged valve discs and parts of the adjacent valves or equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Bronze body swing check valves shall be used for water services which are 1-1/2” or smaller.

B. Globe style silent check valve shall be used in water services 2” and larger.

3.2 INSTALLATION

A. Valves shall be installed in accordance with the manufacturer’s recommendations as outlined in their Installation, Operation and Maintenance Manuals. Valves shall be installed to permit easy access for servicing valve and oil dashpots.

B. Valves in this section are for use with water services and are not approved for pneumatic service.

C. Swing check valves shall be installed in accordance with the manufacturer’s recommendations.

END OF SECTION 15108
ART CENTER AND SATELLITE COOLING PLANT  
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD  
BAKERSFIELD, CA

SECTION 15140 - SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies pipe and equipment hangers, brackets, and supports. Pipe supports shall be furnished complete with all necessary inserts, bolts, nuts, rods, washers and other accessories. Piping seismic restraints are specified in Section 15141.

B. Operating Conditions: The hangers and supports specified in this section are provided to resist pipe loads occurring primarily in the downward (gravity) direction. For the purpose of pipe hanger and support selection, this section establishes pipe support classifications based on the operating temperatures of the piping contents. Pipe support classifications are as follows:

1. Cold Systems: 33°F to 59°F.
2. Ambient Systems: 60°F to 119°F.
3. Hot Systems: 120°F to 250°F.

C. Hanger and Support Selection:

1. In certain locations, pipe supports, anchors, and expansion joints have been indicated on the Drawings where possible, but no attempt has been made to indicate every pipe support, anchor and expansion joint. It shall be the Contractor’s responsibility to provide a complete system of pipe supports, to provide expansion joints, and to anchor all piping, in accordance with the requirements set forth herein. Additional pipe supports may be required adjacent to expansion joints, couplings, or valves.

2. The Contractor shall select pipe hangers and supports as specified in this Section. Stock hanger and support components shall be used wherever practical. Selections shall be based upon the pipe support classifications specified in this Section; the piping insulation thickness specified in Section 15250, and any special requirements, which may be specified in the Project Specification.

3. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support to be used at each hanger point.

4. All piping shall be rigidly supported and anchored so there is no movement or visible sagging between supports.

5. Hangers and supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration should be given to the following conditions:

   a. Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.
   b. Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
   c. Reaction forces due to the operation of safety or relief valves.
   d. Wind loadings on outdoor piping.

6. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, indicated or required, the outside diameter of insulation.

7. Where negligible movement occurs at hanger locations, rod hangers should be used for suspended lines, wherever practical. For piping supported from below, bases, brackets or structural cross members should be used.
8. Hangers for the suspension of size 2-1/2 inches and larger pipe and tubing shall be capable of vertical hanger component adjustment under load.
9. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment.
10. Where there is horizontal movement at a suspended type hanger location, hanger components shall be selected to allow for swing. The vertical angle of the hanger rod shall not, at any time, exceed 4 degrees.
11. There shall be no contact between a pipe and hanger or support component of dissimilar metals when supporting copper tubing by use of felt isolator inserts, rubber, plastic or vinyl coated, or felt lined hanger and support components.
12. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
13. Unless otherwise specified, pipe support components shall not be attached to pressure vessels.
14. Plumber’s tape shall not be used to support piping.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following standards for manufacturer and installation requirements. They are a part of this section in their entirety or as specifically modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail. In case of conflict between the listed documents, the more stringent requirement shall prevail.

- ASME B31.1 Power Piping
- ASME B31.2 Fuel Gas Piping
- ASME B31.9 Building Services Piping
- ASTM E84 Surface Burning Characteristics of Building Materials, Test Method for
- MSS SP58 Pipe Hangers and Supports - Materials, Design and Manufacturer.
- MSS SP69 Pipe Hangers and Supports - Selection and Application.
- NFPA 13 Installation of Sprinkler Systems.
- NFPA 14 Installation of Standpipe and Hose Systems.
- UL 203 Pipe Hanger Equipment for Fire Protection Service

B. Supports for Mechanical Systems and Plumbing Piping Systems: In conformance with MSS SP-58 and SP-69.

C. Supports for Sprinkler Piping: In conformance with minimum requirements as established in NFPA 13.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Provide:

1. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
2. Product Data: Provide manufacturers catalog data including load capacity.
3. Design Data:

   a. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
b. For every piece of material or equipment with an operating weight of 500 pounds or more, the Contractor shall submit a design support drawing prepared and sealed by a California Licensed Structural Engineer.

c. All designs shall conform to 2001 CBC requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. Standard pipe supports and components shall be manufactured by B-Line, ITT Grinnell, Pipe Shields Incorporated, Unistrut, Tolco, Inc. or equal.

B. Fire Protection Piping:

2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

C. Plumbing Piping - DWV:

1. Conform to ASME B31.9, MSS SP58 and MSS SP69.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, and split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, felt lined or vinyl coated.

D. Plumbing Piping - Water:

1. Conform to ASME B31.9, MSS SP58 and MSS SP69.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, and split ring.
3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Copper Pipe Support: Carbon steel ring, adjustable, felt lined or vinyl coated.

E. Hydronic Piping:

1. Conform to ASME B31.9, MSS SP58 and MSS SP69.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring, spring hanger.
3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis, spring hanger.
5. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger, spring hangers.
6. Pipe Anchor:
   a. Manufacturer shall be Piping Technology Products, ITT Grinnell, B-Line, or equal.
   b. Factory fabricated, double saddle, welded construction, made of high strength carbon steel.
   c. Anchor shall be capable of withstanding a deadweight (downward force) equivalent to the weight 28 feet of Sch.40 pipe filled with water of the pipe size it supports.
   d. Provide with critical dimensions as indicated on the Drawings.
   e. Anchors shall be degreased, and deburred, shop coat primed and ready for welding when delivered to the jobsite.
   f. Pipe anchor shall be capable of withstanding a lateral seismic force equal to 0.6 times the deadweight force.
   g. Pipe anchor shall be capable of withstanding an axial thrust load equal to 1/2 of the deadweight force.

7. Pipe Slide Support Assembly:
   a. Manufacturer shall be Piping Technology Products, ITT Grinnell, B-Line, or equal.
   b. Factory fabricated, (2) piece assembly, as indicated on the Drawings.
   c. Top piece shall consist of saddle support with double U-bolt hold down assembly. Assembly shall be completely factory fabricated and have slots for the four (4) hold down bolts of the bottom assembly. Slots shall be sized as follows:
      2) Refer to the front and side view shown on the drawings.
   d. Assembly shall be capable of withstanding a downward deadweight force equal to the weight of 28 feet of Schedule 40 pipe filled with water of the pipe size it supports. Assembly shall also be capable of withstanding a lateral or tangential seismic horizontal force equal to 0.6 times the deadweight.

8. Pipe Guide Assembly:
   a. Manufacturer shall be Piping Technology Products, ITT Grinnell, B-Line, or equal.
   b. Factory fabricated, two (2) piece, welded construction, and made entirely of carbon steel.
   c. Unit shall consist of retainer outer tube and spider slide/pipe clamp assembly.
   d. Assembly shall be capable of withstanding a downward deadweight force equal to the weight of 28 feet of Schedule 40 pipe filled with water of the pipe size it supports. Assembly shall also be capable of withstanding a lateral or tangential seismic horizontal force equal to 0.6 times the deadweight.
9. Elbow Supports:
   a. Welded steel pipe stand with steel base plate anchored and grouted to floor, seismic spring support and welded steel extension off pipe elbow. Use U-bolt cradle where support is below horizontal pipe; refer to the Drawings.
   b. Spring shall have minimum 2” deflection.

10. Roof Piping Supports:
   a. Manufacturer shall be Cooper B-Line CB Series.
   b. The support shall be designed to support minimum of two pipes at any specified height or width.
   c. The support shall be designed for installation without roof penetrations, flashing or damage to roofing material. Provide isolation pads below all supports per manufacturers recommendations.
   d. The supports shall be spaced according to mechanical drawings or as recommended by the manufacturer.
   e. Materials:
      1) Curb base must be made of 100% recycled rubber and polyurethane prepolymer with a support capacity of 2,500 pounds per linear foot of support.
      2) Dimensions:
         a) Width shall be 6 inches
         b) Height shall be 6.75 inches
         c) Length shall be as required to support piping
      3) Steel frame shall be 12 gauge strut galvanized per ASTM A653.
      4) Attaching hardware shall be Zinc-plated threaded rod, nuts and attaching hardware per ASTM B633.
      5) Performance characteristics:
         a) Density shall be 0.6 oz/cu in per ASTM C642
         b) Durometer Hardness shall be 65A ± 7 per ASTM D2240
         c) Tensile Strength shall be 210 psi minimum per ASTM D412
         d) Compression Deformation shall be 10% at 70psi and 68°F per ASTM D395
         e) Brittleness at Low Temperature shall be -40°F per ASTM D746
         f) Freeze and thaw when exposed No loss after 50 cycles shall be ASTM C672 to de-icing chemicals
         g) Coefficient of Thermal Expansion shall be 8 x 10-6 in/in/°F (min) per ASTM C531
         h) Weathering shall be 70 hours at 12°F per ASTM D573
         i) Pipe clamps shall be channel style, Cooper B-Line B2000 or B2400 series or equal, made of galvanized steel or other material suitable for outdoor use.

F. Natural Gas Piping:
   1. Conform to ASME B31.2, MSS SP58 and MSS SP69.
   2. Hangers for Pipe Sizes 1/2 to 1-1/2”: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Pipe Sizes 2” and over: Carbon steel, adjustable, clevis.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Wall Support for Pipe Sizes 4”: As indicated on the Drawings.
2.2 STRUCTURAL ATTACHMENTS

A. Steel beam clamp with Eye Nut: Beam clamp and eye nut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 28. Grinnell Fig. 292, Carpenter & Patterson Fig. 297, or equal.

B. Welded Beam Attachment: Beam attachment shall be carbon steel and comply with MSS and FEDSPEC Type 22. B-Line B3083, Grinnell Fig. 66, or equal.

C. Welded Steel Bracket: Bracket shall be carbon steel and comply with MSS Type 32 and FEDSPEC Type 33 for medium welded bracket shall comply with MSS Type 33 and FEDSPEC Type 34.

D. Beam “C” Clamp with Locknut and Retaining Strap: Beam clamp and locknut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 19. Tolco Fig. 65 or 66 with Fig. 69 retaining strap, B-Line B3036 with B3362 strap, or equal.

2.3 ACCESSORIES

A. Hanger Rods: Rods shall be carbon steel or 304 stainless steel, threaded on both ends or continuous threaded and sized as specified.

B. Weldless Eye Nut: Eye nut shall be forged steel and shall comply with MSS and FEDSPEC Type 17. Eye nut shall be Grinnell Fig. 290, B-Line B2300, or equal.

C. Welded Eye Rod: Eye rod shall be carbon steel with eye welded closed. Inside diameter of eye shall accommodate a bolt diameter 1/8 inch larger than the rod diameter. Eye rod shall be Grinnell Fig. 278, B-Line B2311, or equal.

D. Turnbuckle: Turnbuckle shall be forged steel and shall comply with MSS and FEDSPEC Type 15. Turnbuckle shall be Grinnell Fig. 230, B-Line B2311, or equal.

E. Metal Framing Channel: Framing channel shall conform to the Metal Framing Manufacturers Association Standard MFMA-1. Framing channel shall be 1-5/8 inches square, roll formed, and 12–gage carbon steel. Channel shall have a continuous slot along one side with inturned clamping ridges. Framing channel shall be Unistrut P-1000 series, Superstrut A-1200 series, or equal.

F. Vinylester Resin Fiberglass Framing Channel: Framing channel shall conform to ASTM E84 and shall be Class 1 fire-rated. Framing channel shall be 1-5/8” square. All channels shall be supplied with integral notches at 1” on center. Notches shall be located on the interior flange to prevent stoppage of pipe clamps and fittings after installation. Seal exposed glass fibers at cuts with manufacturer’s sealant. Framing channel shall be StruTech, Series 200, vinylester resin fiberglass or equal (no known equal).

G. Thermal Pipe Hanger Shield: Thermal shields shall be provided at hanger, support and guide locations on pipe requiring insulation. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer and shall be as specified in Section 15250. The thermal shield shall be the same thickness as the piping system insulation specified in Section 15250. The vapor barrier shield shall be used for cold systems. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.

H. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
PART 3 - EXECUTION

3.1 INSERTS
A. Provide inserts for placement in concrete formwork.
B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.2 PIPE HANGER AND SUPPORT LOCATIONS
A. The Contractor shall locate hangers and supports as near as possible to concentrated loads such as valves, flanges, etc. Locate hangers, supports and accessories within the maximum span lengths specified in the project specifications to support continuous pipeline runs unaffected by concentrated loads.
B. At least one hanger or support shall be located within 2 feet from a pipe change in direction.
C. The Contractor shall locate hangers and supports to ensure that connections to equipment, tanks, etc., are substantially free from loads transmitted by the piping.
D. Where piping is connected to equipment, a valve, piping assembly, etc. that will require removal for maintenance, the piping shall be supported in such a manner that temporary supports shall not be necessary for this procedure.
E. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.
F. Support horizontal cast iron pipe within 18 inches of each joint.
G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor level, not to exceed 8 feet on center spacing.

3.3 INSTALLATION
A. Welded and bolted attachments to the building structural steel shall be provided where required and shall be in accordance with the requirements of SMACNA Seismic Restraint Guide and AISC M016. Unless otherwise specified, there shall be no drilling or burning of holes in the building structural steel.
B. Unless otherwise indicated, attachments to the building concrete shall be in accordance with the requirements of SMACNA Seismic Restraint Guide.
C. Hanger components shall not be used for purposes other than, for which they were designed. They shall not be used for rigging and erection purposes.
D. The Contractor shall install items to be embedded before concrete is poured. Fasten embedded items securely to prevent movement when concrete is poured.

E. Embedded anchor bolts shall be used instead of concrete inserts for support installations in areas below water surface or normally subject to submerging.

F. The Contractor shall install thermal pipe hanger shields on insulated piping at required locations during hanger and support installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer’s recommendations.

G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

H. Support riser piping independently of connected horizontal piping.

I. Provide felt lined inserts for copper piping.

J. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

K. Rollers shall roll freely without binding.

L. Finished floor beneath pipe stand and framing channel post bases shall be roughed prior to grouting. Grout between base plate and floor shall be free of voids and foreign material.

M. Base plates shall be cut and drilled to specified dimensions prior to welding stanchions or other attachments and prior to setting anchor bolts.

N. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

O. Prime coat all exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

P. Unless otherwise indicated, exposed exterior steel pipe supports, channel, and clamps shall have hot dipped galvanized finish of minimum 1.50 ounces per square foot on each side in conformance with ASTM A123.

Q. Welds on pipe supports, either interior or exterior shall be cleaned of flux and finished with a “zinc rich” primer.

R. The Contractor shall adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Stanchions shall be adjusted prior to grouting their base plates.

S. Beam clamps shall not be installed on piping greater than 8 inches in diameter. All beam clamps shall have beam clamp retaining straps.

3.4 EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, thickness as indicated on the Drawings and extending 12 inches beyond supported equipment.

B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.
D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 FLASHING

A. Provide flashing where indicated or necessary.
B. Provide flexible flashing and metal counter flashing where ductwork penetrates weather or waterproofed walls, floors, and roofs.
C. Flash vent and water pipes projecting 12 inches minimum above finished roof surface with lead flashing and cast iron counter flashing, 8 inches minimum clear on sides with 24 x 24 inches sheet size.
D. Flash floor drains in floors with topping over finished areas with 6-lb. lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
E. Seal floor drains watertight to adjacent materials.
F. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms installed in accordance with manufacturer's instructions for sound control.
G. Adjust storm collars tight to pipe with bolts; calk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.6 SLEEVES

A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
B. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
C. Extend sleeves through floors one inch above finished floor level. Calk sleeves.
D. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with fire stopping insulation and calk airtight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
E. Install chrome plated steel escutcheons at finished surfaces.
### SUPPORT SCHEDULE

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<th>PIPE SIZE</th>
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END OF SECTION 15140
SECTION 15170 - ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies alternating current induction motors, to be provided with the driven equipment. Unless specified otherwise, the manufacturer of the driven equipment shall provide electric motors. This section refers to motors by enclosure type as defined in NEMA MG 1, except as noted.

B. All motors:
   1. Shall be the energy efficient type
   2. Totally enclosed fan cooled (TEFC) or open drip proof (ODP) type.
   3. Motors used with variable frequency drives (VFD) shall be provided with shaft grounding.

1.2 QUALITY ASSURANCE

A. General: Motors shall be built in accordance with UL 674, UL 1104, NEMA Standard MG 1, and to the requirements specified.

B. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   - AFBMA 9 Load Ratings and Fatigue Life for Ball Bearings.
   - AFBMA 11 Load Ratings and Fatigue Life for Roller Bearings.
   - ANSI/IEEE 112 Polyphase Induction Motors and Generators.
   - NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies.
   - NEMA ICS 6 Enclosures for Industrial Controls and Systems.
   - NEMA MG 1 Motors and Generators.
   - UL 674 Motors and Generators, Electric, for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F & G.
   - UL 1004 Motors, Electric.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit:
   1. Motor data shall be submitted for each item of motor-driven equipment to be provided under this Contract.
   2. Motor outline, dimensions, and weight.
   3. All motors shall be provided with shaft grounding.
   4. Manufacturer’s general descriptive information relative to motor features.
   5. Where a winding over temperature device is required, provide a response curve for the temperature device.
   6. Operating and maintenance information.
PART 1 - SPECIFICATIONS

1.4 AMBIENT CONDITIONS

A. Unless specified otherwise, motors shall be suitable for continuous operation at an elevation of 100 feet above sea level. Motors to be installed outdoors, exposed to the weather, shall be suitable for continuous operation in a 40°C ambient temperature; motors to be installed indoors shall be suitable for continuous operation in a 40°C ambient temperature.

1.5 WARRANTY

A. Provide minimum two year warranty on all motors. Include coverage of motors and windings.

B. The motor manufacturer shall guarantee all components and workmanship for a period of two years from date of Completion.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Motor nameplates shall be engraved or stamped stainless steel. Information shall include those items enumerated in NEMA Standard MG 1, paragraph 10.37, 10.38 or 20.60, as applicable.

B. Additionally, nameplates for motors 1/2 horsepower and larger shall indicate the AFBMA L-10 rated life for the motor bearings. Nameplates for high efficiency motors shall list the nominal efficiency.

C. Nameplates shall be permanently fastened to the motor frame and shall be positioned to be easily visible for inspection.

2.2 CONSTRUCTION

A. Unless specified otherwise, all motors provided under this specification shall have the following features of construction:

1. Cast iron or steel frames.
2. Cast metal fan blades and shrouds.
3. Stainless steel hardware.
4. Nonhygroscopic leads.

2.3 MOTORS LESS THAN 1/2 HORSEPOWER

A. General: Unless otherwise specified, motors less than 1/2 horsepower shall be squirrel cage, single phase, capacitor start, induction run type. Single phase motors shall have Class B insulation. Small fan motors may be split-phase or shaded pole type. Windings shall be copper.

B. Rating: Unless specified otherwise, motors shall be rated for operation at 115 volts, single phase, 60 Hz, and shall be continuous-time rated in conformance with NEMA Standard MG 1, paragraph 10.35. Dual voltage (115/230) rated motors are acceptable if all leads are brought out to the conduit box. Motors shall be nonoverloading at all points of the equipment.

C. Enclosures: Unless otherwise specified, motors shall have totally enclosed fan-cooled enclosures.
2.4 MOTORS 1/2 HORSEPOWER AND GREATER

A. General:

1. Unless otherwise specified, motors 1/2 horsepower through 250 horsepower shall be 3 phase, squirrel cage, full voltage start induction type.
2. Unless otherwise specified, motors shall have a NEMA MG 1-1.16 design letter B or C torque characteristic as required by the driven equipment’s starting torque requirements.
3. All motors shall be provided with shaft grounding.

B. Rating:

1. Unless otherwise specified, motors shall be rated for operation at 460 volts, 3 phase, 60 Hz, and shall be continuous time rated in accordance with NEMA standard MG 1, paragraph 10.35. Dual voltage (230/460) rated motors are acceptable if all leads are brought out to the conduit box. Unless specified otherwise, motors shall have a service factor of 1.15 and shall not be required to exceed its nameplate rating.
2. Motors for variable frequency systems shall not be required to deliver more than 80 percent of the motor’s service factor rating by any load imposed by the driven machine at any specified operating condition or any condition imposed by the driven machine’s performance curve at maximum operating speed.

C. Enclosure and Insulation:

1. Temperature rise for all motor types shall not exceed that permitted by Note II, paragraph 12.42, NEMA MG 1. The insulation shall be nonhygroscopic.
2. Unless otherwise specified in individual technical sections, all motors shall be totally enclosed, fan cooled with Class F insulation. Motors rated 10 horsepower and larger shall have Class F insulation with Class B temperature rise. All internal surfaces shall be coated with epoxy paint. Aluminum frame motors will not be permitted.

D. Energy-Efficient Motors:

1. All motors shall be energy-efficient motors and shall be designed to comply with the minimum nameplate efficiency in paragraph 3.4 of this section.
2. Motor efficiency shall be tested in accordance with IEEE-112, Test Method B with stray load loss adjustment as modified by NEMA MG 1-12.53 (a) and (b).
3. Motor nameplate efficiency shall conform to the nominal values shown in NEMA MG 1, Table 12-6, and to the minimum acceptable efficiencies listed in Schedule A.

E. Vertical Motors:

1. Unless otherwise specified, vertical motors shall be full voltage with a Type P base specifically designed for vertical installation.
2. Vertical motors shall have solid shafts unless specified otherwise.
3. Vertical motors shall conform to requirements as specified under paragraph 15170-2.4-C.
4. Thrust bearing rating shall be compatible with the loads imposed by the driven equipment.
5. Motors shall match the driven equipment’s characteristics.

F. Conduit Boxes:

1. Conduit boxes shall be cast iron, split construction with threaded hubs.
2. Conduit boxes shall be designed for rotation to permit installation in four positions at least 90 degrees apart.
3. Motors shall be furnished with petroleum-resistant gaskets at the base of the conduit box and between the halves of the conduit box.
4. Motors shall have a grounding lug located within the box for the ground connection.

G. Bearings:
1. Bearings may be oil or grease lubricated ball or angle contact roller bearings rated for a minimum L-10 life of 100,000 hours in accordance with AFBMA 9 or 11 at the ambient temperature specified herein.
2. Motor designs employing cartridge type bearings will not be accepted.
3. Bearings shall be fitted with lubricant fill and drain or relief fittings.
4. All motors shall be provided with shaft grounding.

H. Current Imbalance: Current imbalance shall not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system:
1. Under 5 horsepower: 25 percent.
2. 5 horsepower and above: 10 percent.

I. Special Features:
1. General: Where specified or required by this paragraph, special features, as specified below, shall be provided.
2. Winding Overtemperature Protection:
   a. Stator winding overtemperature protection shall be provided on all motors rated 60 horsepower and larger. Motors rated less than 60 horsepower shall have stator winding overtemperature protection only if required by the specific equipment specification section or if recommended by the driven equipment manufacturer.
   b. Overtemperature protection for motors rated 60 horsepower and larger and other motors, where specified, shall be NEMA MG 1-12.53, Type 1. Overtemperature protection detectors shall be positive thermal protection (PTC) thermistors type with leads brought out to a terminal strip in a NEMA 4 enclosure.
3. Heaters: Where specified, heaters shall be provided in motor enclosures to guard against condensation after shutdown. Headers shall be cartridge or flexible wraparound type. Heaters shall be rated 120 volts, single phase, 60 Hz. The heater rating in watts and volts shall be noted on the motor nameplate or on a second nameplate. Space heater terminals shall be brought to a separate terminal block or pigtails in the conduit box.

J. Motors for Variable Frequency Drives:
1. Motors intended for use with variable frequency drives shall be compatible with the characteristics of the intended variable frequency generators.
3. Motors shall be premium efficiency, inverter duty.
4. All motors shall be provided with shaft grounding.
5. Motors shall be designed to be installed at any distance from their respective variable frequency drives.
6. Refer to specification section 15171 for Variable Frequency Drive requirements.
PART 3 - EXECUTION

3.1 APPLICATION

A. Single phase motors for belted fans 1/20 HP to 1/3 HP: Split phase type.

B. Single phase motors for shaft mounted fans or blowers 1/20 HP to 3/4 HP: Permanent split capacitor type.

C. Single phase motors for pumps and air compressors 1/6 HP to 3/4 HP: Capacitor start type.

D. Single phase motors for shaft mounted fans or blowers 1/3 HP to 3/4 HP: Capacitor start, capacitor run type.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.

C. Check line voltage and phase and ensure agreement with nameplate.

3.3 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

<table>
<thead>
<tr>
<th>HP</th>
<th>3600 RPM</th>
<th>1800 RPM</th>
<th>1200 RPM</th>
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<td>1/6-1/3</td>
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<tr>
<td>1-300</td>
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</table>

3.4 FULL LOAD MOTOR PERFORMANCE SCHEDULES

A. Three Phase - Premium Efficient, Open Drip-Proof

<table>
<thead>
<tr>
<th>HP</th>
<th>Full Load RPM</th>
<th>NEMA Frame</th>
<th>Minimum Nominal Percent Efficiency</th>
<th>Percent Power Factor</th>
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<tr>
<td>60</td>
<td>1200</td>
<td>404T</td>
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<td>20</td>
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<td>256T</td>
<td>92</td>
<td>86</td>
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</table>
### 3.5 FULL LOAD MOTOR PERFORMANCE SCHEDULES

#### A. Three Phase - Premium Efficient, Totally Enclosed, Fan Cooled

<table>
<thead>
<tr>
<th>HP</th>
<th>RPM</th>
<th>Frame</th>
<th>Efficiency</th>
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</tbody>
</table>

END OF SECTION 15170
SECTION 15171 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SCOPE

A. Provide AC inverter type adjustable frequency variable speed drives herein identified as VFDs.

B. The manufacturer shall have a nationwide field service and technical support organization available 24 hours a day from a toll-free telephone number. The field service personnel shall be factory trained with periodic updates and have experience with the same model of VFD’s as specified in this project. Sales representative will not be acceptable to perform this work. Capabilities shall include factory coordinated start-up service and on-site training of customer personnel.

C. Furnish labor and related materials, appliances, tools and equipment necessary for and incident to performing all operations in connection with furnishing, delivery, installation, and start up of Variable Frequency Drive. Variable Frequency Drives shall be designed to match motors on equipment specified in Division 15.

D. The VFD shall have a dual 5% DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the drive from power line transients. The reactor shall be non-saturating (linear) to provide full harmonic filtering throughout the entire load range. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

E. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor’s speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

F. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.

G. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

H. Galvanic and/or optical isolation shall be provided between the VFD’s power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.

I. VFD shall minimize the audible motor noise through the used of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

J. The material herein shall be of new and from domestic manufacturer. The VFD for the air handling unit shall be provided by the air handling unit manufacturer and mounted in the factory.
1.2  SUBMITTALS

A.  Refer to Section 15010 for additional requirements.

B.  Provide:

1.  Shop drawings with elevation, layout plan to scale, front and side views of motor control center enclosure with overall dimensions, weights, enclosures type. Include conduit entrance location and requirements; nameplate legends; size and number of bus bars per phase, and ground; forced-ventilation fan sizes and locations, ventilation filters, electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components. VFD UL NEMA 4 enclosure data for VFD’s installed outdoors.

2.  Contractor shall make sure that the each VFD and any associated additional equipment will fit in the available space.

3.  Technical cut-sheets, product data on adjustable frequency controllers, relays, pilot devices and switching and over-current protective devices.

4.  Manufacturer’s installation and operating instructions.

5.  Start-up service report.

C.  The manufacturer shall include a written statement that the submitted equipment, hardware or accessory complies with the requirement of this specification. The manufacturer shall resubmit this specification section showing compliance with each respective paragraphs and specified items and features in this specification. All exceptions shall be clearly identified by referencing respective paragraph and other requirements along with proposed alternative.

1.3  QUALITY ASSURANCE

A.  The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

B.  American National Standards Institute, Inc. (ANSI) Publication:

1.  C57.13-78 Requirements for Instrument Transformers

C.  Institute of Electrical and Electronic Engineers, Inc. (IEEE) Publication:

1.  519-92 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

D.  National Electrical Manufacturer's Association (NEMA) Publications:

1.  NEMA AB 1 Molded Case Circuit Breakers.
2.  NEMA ICS 2 Industrial Control Devices, Controllers, and Assemblies.
4.  NEMA ICS 6 Enclosures for Industrial Controls and Systems.

E.  National Fire Protection Association (NFPA) Publication:

1.  70-96 National Electrical Code (NEC)
F. State of California Administrative Code:
   1. Title 24, Part 3, CCR, 1998 California Electrical Code

G. Underwriters Laboratories (UL) Publications:
   1. UL 198C High-Intensity Capacity Fuses; Current-Limiting Types.
   2. UL 198E Class R Fuses.

H. Perform Work in accordance with NEMA ICS 2.3 & per ISO-9000 certified quality assurance procedures.

I. All functions of the VFD shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to VFD output and it shall test all inputs, outputs and program execution specific to this application.

J. The control system manufacturer shall be fully certified by the International Standards Organization per ISO 9000. Proof of this certification and date of the most recent audit shall be furnished at time of submittal.

K. At the time of submittal, the contractor shall obtain and coordinate necessary information from the driven equipment manufacturer such as motor efficiencies over the operating speed range. The VFD manufacturer shall provide an analysis showing overall efficiency, job specific load profile, staging points, and horsepower / kilowatt consumption over the operating speed range.

L. Every VFD unit shall be designed, constructed and tested in accordance with NEMA, UL, NEC and IEEE recommendations.

M. Every VFD and all supplied options shall be UL approved and listed according to UL 508. The controller shall have a UL listed label attached inside the enclosure as verification.

1.4 WARRANTY:

A. The drive manufacturer shall guarantee the operation of the drive against failure due to defects a minimum period of 36 months from the date of acceptance by Owner.

B. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. Extended warranties shall be made available for purchase by the owner for a total period of up to 6 years from date of acceptance of the VFD.

1.5 OPERATION AND MAINTENANCE MANUAL

A. Submit six (6) copies of operation programming and maintenance manuals.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

C. Operation Data: Include instructions for programming, starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions

D. Maintenance Data: Include routine preventive maintenance schedule.
E. Submit operation programming and maintenance manual under provisions of Section 16010.

1.6 TRAINING AND INSTRUCTION TO OWNER’S REPRESENTATIVE

A. Instruction for a minimum of eight (8) hours by a certified, factory trained instructor shall be provided for items specified in this section. Training and instruction time shall be in addition to that required for field start-up service.

B. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance and shutdown of equipment.

C. Before final inspection, instruct the Owner’s designated personnel in operation, adjustment, and maintenance of products at agreed upon times. Furnish the services of competent instructors to give full instruction to Owner’s personnel in the adjustment, operation, and maintenance of equipment, including pertinent safety requirements. Each instructor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

D. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with the Owner’s personnel in detail to explain all aspects of operation and maintenance.

E. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store and protect products under provisions of Division 1.

B. Deliver individually wrapped VFD’s for protection.

C. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle in accordance with manufacturer's written instructions.

1.8 MANUFACTURERS’ EXPERIENCE

A. The manufacturer shall have been specialized in the production of this type of equipment for a period of at least 5 years.

B. The VFDs and other electrical gear herein specified shall be supplied by the VFD manufacturer who shall coordinate and verify their operation.

1.9 MAINTENANCE SERVICE

A. Furnish service and maintenance of variable frequency drives for one (1) year from the date of completion and final acceptance by the Owner. A minimum of two (2) job-site trips will be required in the first year spaced six (6) months apart.
1.10 SPARE PARTS

A. Keys: Furnish two (2) each to Owner.
B. Fuses: Furnish two (2) spare of each size and type used.
C. Filters: Furnish one spare filter for each fan filter kit.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer shall be Reliance, Danfoss, Cutler Hammer or Yaskawa.
B. The drive shall be Pulse Width Modulated (PWM) transistorized inverter using Insulated Gate Bipolar Transistors (IGBT) and must be fully digital.
C. The alternating current variable speed drive shall include the microprocessor based variable controller, the required signal logic and control. The drive component specified including the variable frequency controller and its associated microprocessor control system shall be of the same manufacture. Coordinate with air handling unit supplier to ensure compatibility between drive and AC motors.
D. The drive shall be UL listed and CSA approved, and shall comply with all applicable requirements of the latest standard of ANSI, IEEE and NEMA.
E. VFD Enclosure:
   1. The drive shall be mounted in UL NEMA 12 enclosure.
   2. For VFD’s mounted outdoor, the drive shall be mounted in UL NEMA 3R, forced air ventilated enclosure. Enclosure shall be Hoffman Model WF-LP or equal.
F. The cabinet shall be front access only. The unit shall be suitable for operation in ambient temperature - 14°F to 104°F (up to 122°F with cover removed).

2.2 VARIABLE FREQUENCY DRIVE

A. Standard Features
   1. Main input power shall be as indicated on the drawings.
   2. The drive shall have a tolerance for voltage ± 10% and frequency ± 2Hz. Overload current shall be 100% continuous and 110% for 1 minute.
   3. Interrupting rating (AIC): 100,000 AIC (RMS symmetrical) unless otherwise noted. The use of input fuses to achieve this rating shall not be acceptable. Contractor to verify the rating from the short circuit study prior to furnishing submittal.
   4. The cooling fan shall be in operation when the VFD is in operation.
   5. Shall have an adjustable retry function after a fault, both number of attempts (at least 10) and time between (1-10 sec).
   6. Shall have an analog input filter adjustment to limit the effects of noise on the control signal.
   7. Shall have the ability to automatically restart after an over current, over voltage, under voltage, or loss of input signal protective trip. The number of restart attempts and trials shall be programmable.
8. Shall have the following user selectable contingencies in the event of loss of analog control signal while the drive is running before loss:
   a. Trip with a signal loss fault.
   b. Run at user selected percentage of the last valid frequency signal.

9. Shall be equipped with manual/auto keys on touchpad.

10. Shall have the capability of storable special custom user setting.

11. Shall restart into a rotating motor operating in either the forward or reverse direction and match that frequency.

12. Shall have adjustable soft stall (10% - 150%) which reduces frequency and voltage of the inverter to sustain a run in an overload situation.

13. Shall have adjustable UL listed electronic overload protection (10% - 100%). The drive shall have a custom programmable volt/hertz pattern.

14. Shall have capability of over-riding DDC input and ramping to full speed via remote contact closure wired to drive terminal blocks.


B. Protective Features

1. Shall have integral input circuit breaker with minimum interrupting rating not less than 110% of the available fault level. Circuit breaker shall be by Square D, General Electric, or equal. The circuit breaker operating mechanism shall be lockable and readily accessible on the outside of the enclosure.

2. The drive shall be capable of re-setting faults remotely and locally.

3. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units.

4. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

5. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

6. When appropriate, provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode. A VFD disconnect can be substituted for the 3rd contactor. Auto-bypass shall not be utilized unless the contractor verifies that the BAS system can override the VAV boxes to open to the full-cooling position before engaging the line start to provide full speed to the motor. This is recommended to avoid ductwork over-pressurization.

7. The drive shall be programmable to alert the following alarms:
   a. Over torque alarm,
   b. Motor overload pre-alarm
   c. Undercurrent alarm
   d. Over current pre-alarm
   e. Communication error alarm

8. The drive shall identify and display the following faults:
a. Over current (350% instantaneous or 170% RMS) during normal run, acceleration or deceleration trip.
b. Over current on the DC Bus during normal run trip, acceleration trip, or deceleration trip.
c. Over voltage (130% of VFD’s rated voltage) during normal (constant speed) run trip, acceleration trip, or deceleration trip.
d. Under voltage (65% of the VFD’s rated voltage) trip.
e. Over temperature.
f. Ground Fault either running or at start
g. Emergency off trip message.
h. RAM, ROM, CPU error
i. Communication interruption error
j. Output current detection circuit error
k. Over torque trip

9. The display shall have four lines, with 20 characters on three lines and eight large characters on one line. Four live meters shall be available for quick access to the most important usable data. These can be used for trouble-shooting or for simple status check of the system being controlled. All meters shall be in plain English and shall be displayed in the proper engineering units, e.g. “CFM”, “GPM”, “In wg” and so forth.

C. Monitor Functions

1. The drive digital display shall be capable of displaying the following: frequency in Hz or %, % current, current amps, % voltage I/O, voltage in volts I/O, RPM, GPM, I/O Watts, torque, and input reference signal, kWh, in wg, cfm.
2. The VFD shall include a standard EIA-485 communications port and capabilities to be connected at a future date to the campus energy management system at no additional cost to the owner. The connection shall be software selectable by the user.
3. As a minimum, the following points shall be controlled and/or accessible:
   a. VFD Start/Stop	en Speed reference
c. Fault diagnostics
d. Meter points
   1) Motor power in HP
   2) Motor power in kW
   3) Motor kW-hr
   4) Motor current
   5) Motor voltage
   6) Hours run
   7) Feedback signal #1
   8) Feedback signal #2
   9) DC link voltage
   10) Thermal load on motor
   11) Thermal load on VFD
   12) Heatsink temperature

4. Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VFD.
5. LonWorks communication shall be available for factory or field installation within the VFD.
6. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
7. If the temperature of the VFD’s heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD’s heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.

8. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.

9. The VFD shall store in memory the last 10 faults and related operational data.

10. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

11. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.

12. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.

13. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Inspect installation for dimensions, physical damage, proper alignment, anchorage and grounding. Check proper installation and tightness of connections for starters.

B. Protect all equipment during delivery, storage, installations and at all times during construction.

3.2 INSTALLATION

A. Install per manufacturer recommendation and instructions.

B. Coordinate with equipment supplier to ensure compatibility between variable frequency drive and the motor supplied with the equipment.

C. Mount and wire the drives in locations indicated on the drawings.

D. Maintain code required electrical clearance around all VFD cabinets.

3.3 INSTRUCTION MANUAL AND SPARE PARTS

A. Operation data including instructions for programming, starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

B. Maintenance manual including routine preventive maintenance schedule

C. The manufacturer shall supply and recommended list of spare parts; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals. Spare parts shall include at least:

1. Keys: Furnish two each.
2. Fuses: Furnish two spare of each size and type used.
3. Filters: Furnish one spare filter for each fan filter kit.

3.4 START UP
   A. Provide start up service of the VFD manufacturer’s engineer for inspection of installation, to do the initial drive equipment setting and energize, and adjustment at no additional cost to the Owner.
   B. After completion of inspections and settings, the engineer shall also provide training and instructions to Owner personnel for a minimum period of four (4) hours.

3.5 ADJUSTING
   A. Make final adjustments to installed VFDs to assure proper operation of fans.

3.6 POST OPERATING INSTRUCTIONS:
   A. User operating instructions shall be provided prominently displayed on a separate sheet located next to the VFDs.

3.7 CLEANING AND REPAIR
   A. Clean interior and exterior prior to installation.
   B. Damage to component shall be repaired in the factory.

END OF SECTION 15171
SECTION 15190 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies mechanical identification for equipment, piping systems and ductwork specified in Division 15. The following are included: nameplates, tags, stencils and pipe markers.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
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<tr>
<td>ANSI A13.1</td>
<td>Scheme for the Identification of Piping Systems.</td>
</tr>
<tr>
<td>MIL-STD-810C</td>
<td>Environmental Test Methods.</td>
</tr>
</tbody>
</table>

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit the following:

1. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
2. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
3. Product Data: Provide manufacturers catalog literature for each product required.

1.4 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

B. Record actual locations of tagged valves on Record Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer shall be Seton Name Plate Company, WH Brady Company or equal.

2.2 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved white letters on black background color.
2.3 TAGS

A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

B. Chart: Typewritten letter size list in anodized aluminum frame.

2.4 STENCILS

A. Stencils: With clean cut symbols and letters of following size:

1. 3/4 to 1-1/4 inch O.D. of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch O.D. of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
3. 2-1/2 to 6 inch O.D. of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
4. 8 to 10 inch O.D. of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
5. Over 10 inch O.D. of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.

B. Stencil Paint: Provide semi-gloss enamel, colors conforming to ANSI A13.1 unless otherwise specified.

2.5 PIPE MARKERS

A. Plastic markers for coding pipe shall conform to ANSI A13.1. Markers shall be the mechanically attached type that are easily removable and firmly attached; they shall not be the adhesive applied type. Markers shall consist of pressure sensitive legends applied to plastic backing which is strapped or otherwise mechanically attached to the pipe. Legend and backing shall be resistant to petroleum based oils and grease and shall meet criteria for humidity, solar radiation, rain, salt, fog and leakage fungus, as specified by MIL-STD-810C. Markers shall withstand a continuous operating temperature range of -40°F to 180°F. Plastic coding markers shall not be the individual letter type but shall be manufactured and applied in one continuous length of plastic.

B. Markers bearing the legends on the background colors specified in ANSI A13.1 shall be provided in the following letter heights:

<table>
<thead>
<tr>
<th>Outside Pipe Diameter*</th>
<th>Letter Height, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1-1/2</td>
<td>1/2</td>
</tr>
<tr>
<td>1-1/2 through 3</td>
<td>1-1/8</td>
</tr>
<tr>
<td>Greater than 3</td>
<td>2-1/4</td>
</tr>
</tbody>
</table>

* Outside pipe diameter shall include insulation and jacketing

In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

C. Tracer tape shall be 6 inches wide, colored the same as the background colors as specified in ANSI A13.1, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length.
PART 3 - EXECUTION

3.1 PREPARATION
   A. Degrease and clean surfaces to receive adhesive for identification materials.
   B. Prepare surfaces for stencil painting.

3.2 INSTALLATION
   A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
   B. Install tags with corrosion resistant chain.
   C. Apply stencil painting where required.
   D. Install plastic pipe markers in accordance with manufacturer's instructions.
   E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
   F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
   G. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
   H. Identify control panels and major control components outside panels with plastic nameplates.
   I. Identify room sensors relating to terminal boxes or valves with nameplates.
   J. Identify valves in main and branch piping with tags.
   K. Tag automatic controls, instruments, and relays. Key to control schematic.
   L. Identify piping, concealed or exposed with plastic pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.
   M. Identify ductwork with stencilled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
   N. Provide each hose bibb with a red plastic laminate sign stating “DANGER - UNSAFE WATER”. The sign shall be mounted within 12” of the hose bibb outlet.
   O. Provide a red plastic laminate sign with 1” white letters stating “EMERGENCY GAS SHUT-OFF”. The sign shall be mounted next to building gas shut off valve.

END OF SECTION 15190
SECTION 15250 - INSULATION FOR EXPOSED PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 0 Specification Sections, apply to this Section.

1.2 DESCRIPTION

A. This section specifies insulation for exposed piping and related equipment and appurtenant surfaces.

1.3 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM B209 Aluminum and Aluminum-Alloy Sheet and Plate.
- ASTM C533 Calcium Silicate Block and Pipe Thermal Insulation.
- ASTM D1621 Compressive Properties of Rigid Cellular Plastics.
- ASTM D1056 Flexible Cellular Materials.
- ASTM C533 Mineral Fiber Blanket and Felt Insulation.
- ASTM C612 Mineral Fiber Block and Board Insulation.
- ASTM C547 Mineral Fiber Preformed Pipe Insulation.
- ASTM C534 Performed Flexible Elastomeric Cellular Thermal Insulation In Sheet and Tubular Form.
- ASTM C552 Cellular Glass Thermal Insulation.
- ASTM C335 Steady State Heat Transfer Properties of Horizontal Pipe Insulation
- ASTM E84 Surface Burning Characteristics.
- ASTM D2842 Water Vapor Transmission of Rigid Cellular Plastics.
- MICA National Commercial and Industrial Insulation Standards

B. Manufacturer: The insulation manufacturer’s quality system, including its implementation, shall meet the requirements of ISO 9002.

C. Applicator: Company specializing in performing the work of this section with minimum three years experience.

D. Store insulation in original wrapping and protect from weather and construction traffic.

E. Protect insulation against dirt, water, chemical, and mechanical damage.

F. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
1.4 SUBMITTALS

A. The following information shall be provided in accordance with Section 15010:

1. Manufacturer and manufacturer’s type designation.
2. Samples, for each insulation material type, of typical jacket and closures for fittings, valves, and appurtenances.
3. Descriptive literature and catalog data for materials to be used showing methods of installation.
4. Certification of ratings for water vapor transmission and puncture and stiffness.

PART 2 - PRODUCTS

2.1 GENERAL

A. Piping insulation shall be as specified in paragraph 15250-3.03, wrapped with reinforced all service vapor retarder jacketing. Insulation for valves, strainers, fittings, expansion joints, flanges and other connections shall be segmented sections, molded, or blanket type coverings of the specified type and thickness of pipe insulation. Equipment insulation shall be cellular glass rigid board type cut to fit the surface.

B. All insulation shall meet fire and smoke hazard ratings as tested under procedure ASTM E-84, NFPA 255, and UL 723 and shall not exceed flame spread rating of 25 and maximum smoke developed rating of 50.

2.2 CELLULAR GLASS, RIGID

A. Manufacturer shall be Pittsburgh Corning Foamglas or equal (no known equal).

B. Insulation: ASTM C552; cellular glass, noncombustible.

1. ‘K’ value: ASTM C177, 0.32 at 75°F.
2. Maximum service temperature: 900°F.
3. Maximum moisture absorption: ASTM C240, 0.2 percent by volume.
4. Water vapor permeability: ASTM E96, 0.00 perm-in.
5. Density: 8.0 lb/cu ft density.
6. Maximum flame spread: ASTM E84; 5.
7. Maximum smoke developed: ASTM E84; 0.

C. Joint Sealant:

1. Joints shall be sealed using Pittsburgh Corning Pittseal 444N or 727 sealant, or equal.
2. Sealant shall be a non-curing butyl sealant.
3. Tape shall be 0.75” wide fiber reinforced tape such as Scotch #880, or equal.

D. Weather barrier mastic shall be Pittcote 404 coating by Pittsburgh Corning Corporation, or equal.

2.3 CELLULAR FOAM

A. Manufacturer shall be Armaflex, Rubatex or equal (no known equal).
B. Insulation: ASTM C534; Type I, flexible, cellular elastomeric, tubular material. ASTM C534; Type II, flexible, cellular elastomeric, sheet material.

1. 'K' value: ASTM C177 or C518; 0.28 at 75 °F.
2. Minimum service temperature: -40 °F.
3. Maximum service temperature: 220 °F.
4. Maximum moisture absorption: ASTM D1056; 3.0 percent (pipe) by volume, 6.0 percent (sheet) by volume.
5. Moisture vapor transmission: ASTM E96; 0.20 perm inches.
7. Maximum smoke developed: ASTM E84; 50.

C. Fitting Insulation: Mitered sections of pipe insulation or cut sheets of same material.

D. Elastomeric Foam Adhesive:

1. Manufacturers: Armstrong 520, or equal.
2. Air dried, contact adhesive, compatible with insulation.

E. Finish: Plasticized lacquer, white.

2.4 INSERTS

A. Polyurethane Rigid Foam Insulation:

1. Manufacturer shall be Trymer 9501, Insul Therm, or equal (no known equal).
2. Insulation:
   a. Minimum Service Temperature: -320°F.
   b. Maximum Service Temperature: 300°F.
   c. Moisture Absorption: ASTM D2842, .05 lb/ft².
   d. ‘K’ value: ASTM C518; 0.14 at 75°F.
   e. Maximum Flame Spread: ASTM E84; 20.
   f. Maximum Smoke Density: ASTM E84; 50.
   g. Compressive Strength: ASTM D1621; 28 parallel, 20 perpendicular.

2.5 JACKETS


1. Thickness: 0.020 inch sheet.
2. Finish: Smooth finish for all piping and equipment on the equipment pad. Embossed finish for all piping and equipment on roof.
4. Fittings: 0.020 inch thick die shaped fitting covers with factory attached protective liner.
5. Metal Jacket Bands: 3/4 inch wide; 0.010 inch thick aluminum.

B. PVC Plastic (All Insulated Piping Inside the Central Plant):

1. Manufacturers for White PVC Jackets shall be Proto Corporation LoSMOKE 20, Manville Zeston 2000 PVC, Foster’s Speedline 25/50 or equal (no known equal).
2. Jacket: ASTM C921, One piece molded type fitting covers and jacketing; high gloss white color unless otherwise indicated.
   a. Minimum Service Temperature: 0°F.
   b. Maximum Service Temperature: 150°F.
   c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
   d. Maximum Flame Spread: ASTM E84; 25.
   e. Maximum Smoke Developed: ASTM E84; 50.
   f. Thickness: 0.020 inch.
   g. Connections: Vapor seal mastic.

3. Covering Adhesive Mastic:
   a. Manufacturer shall be Manville Zeston Perma-Weld, Ceel-Co 300 or equal (no known equal).
   b. Compatible with insulation and jacket.

C. Canvas Jacket: UL listed

   1. Fabric: ASTM C921, 6 oz/sq yd, plain weave cotton treated with dilute fire retardant lagging adhesive.
   2. Lagging adhesive shall be compatible with insulation.

PART 3 - EXECUTION

3.1 PIPE INSULATION INSTALLATION, GENERAL

A. General: Insulation shall be applied over clean, dry surfaces. Double layout insulation, where specified or required to achieve the specified surface temperature, shall be provided with staggered section joints.

B. Pipe Supports and Shields: Unless otherwise specified, thermal pipe hanger shields shall be provided by the Contractor and installed during pipe support installation. Where thermal pipe hanger shields are used, apply the following to all butt joints:

   1. On cold water or chilled water, the Contractor shall apply a wet coat of vapor barrier lap cement on all butt joints and seal the joints with a minimum 3 inch wide vapor barrier tape or band.

C. Protection: Insulation and jackets shall be protected from crushing, denting, and similar damage during construction. Vapor barriers, shall not be penetrated or otherwise damaged. Insulation, jacket, and vapor barriers damaged during construction shall be removed and new material shall be installed.

D. Tightly butt longitudinal seams and end joints. Bond with adhesive.

E. Stagger joints on double layers of insulation.

F. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.

G. Apply insulation with a minimum number of joints.

H. Apply insulation with integral jackets as follows:

   1. Pull jacket tight and smooth.
2. Cover circumferential joints with butt strips, at least 3 inches wide, and of same material as insulation jacket. Secure with adhesive and outward clinching staples along both edges of butt strip and space 4 inches on center.

3. Longitudinal Seams: Overlap seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches on center.

   a. Exception: Do not staple longitudinal laps on insulation applied to piping systems with surface temperatures at or below 35 deg F.

4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints, over staples, and at ends butt to flanges, unions, valves, and fittings.

5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.

6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere, staple, and seal. Extend patch at least 2 in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

I. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

J. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

K. Fire-Rated Walls and Partitions Penetrations: Terminate insulation at penetrations through fire-rated walls and partitions. Seal insulation ends with vapor barrier coating. Seal around penetration with firestopping or fire-resistant joint sealer. Refer to Division 7 for firestopping and fire-resistant joint sealers.

L. Flanges, Fittings, and Valves - Interior Exposed and Concealed: Coat pipe insulation ends with vapor barrier coating. Apply premolded, precut, or field-fabricated segments of insulation around flanges, unions, valves, and fittings. Make joints tight. Bond with adhesive.

   1. Use same material and thickness as adjacent pipe insulation.
   2. Overlap nesting insulation by 2 inches or 1-pipe diameter, which ever is greater.
   3. Apply materials with adhesive, fill voids with mineral fiber insulating cement. Secure with wire or tape.
   4. Insulate elbows and tees smaller than 3 inches pipe size with premolded insulation.
   5. Insulate elbows and tees 3 inches and larger with premolded insulation or insulation material segments. Use at least 3 segments for each elbow.
   6. Cover insulation, except for metal jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.
   7. Cover insulation, except for metal jacketed insulation, with 2 layers of lagging adhesive to a minimum thickness of 1/16 inch. Install glass cloth between layers. Overlap adjacent insulation by 2 inches in both directions from joint with glass cloth and lagging adhesive.

M. Inserts and Shields:

   1. Inserts for piping conveying fluids below ambient temperature shall be polyurethane as specified in paragraph 15250-2.04.
   2. Application: Piping 2” diameter or larger.
3. Shields: Minimum 18ga. galvanized steel between hangers and inserts. Minimum length 9”. Pipes 6” and 8” shall be 12” long. Pipes 10” and larger shall be 18” long.
4. Insert Location: Between support shield and pipe and under the finish jacket.
5. Insert Configuration: Minimum 6” long, of same thickness and contour as adjoining insulation; may be factory fabricated.

N. Insulate all chilled water system appurtenances so that no condensation forms, i.e., drain lines, sensing lines, thermometer stems, gauge stems, chemical pot feeder lines, etc.

O. Flashing:
1. Flashing shall be provided at jacket penetrations and terminations. Clearance for flashing shall be provided between insulation system and supports.
2. A heavy tack coat of sealant shall be troweled over the insulation, extending over the jacket edge 1 inch and over the pipe of protrusion 2 inches. Reinforcement shall be stretched over the tack coat after clipping to fit over pipe and jacket. Clipped reinforcing shall be strapped with a continuous band of reinforcing to prevent curling. Sealant shall be troweled over the reinforcement to a minimum thickness of 1/8 inch.
3. Aluminum caps shall be formed to fit over the adjacent jacketing and to completely cover coated insulation. Cap shall be held in place with a jacket strap.

P. Foam Glass Insulation:
1. Foam glass insulation shall be applied with all joints sealed full depth with joint sealant. All joints shall be tightly filled with no voids. Joint sealer shall not be used to fill voids or cracks. Insulation shall be secured with reinforced tape when jacketing is applied separately, two strips of tape per section of insulation. The tape shall overlap by 50%. Staples shall not be used. Secure insulation and jacket with two bands per insulation section evenly spaced.
2. Fittings shall be insulated in a manner similar to that of piping.

Q. Hangers and Supports:
1. Insulate and vapor seal hangers, supports, anchors, and other items that are secured directly to cold surfaces to prevent condensation.
2. Protect insulation from physical damage at points of support where insulation must carry load imposed by support. Coordinate with types of hangers and supports used.

3.2 JACKETS
A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 1-1/2 inches laps at longitudinal joints and 3 inch wide butt strips at end joints.
1. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.

B. Interior Insulation:
1. Pipe: Insulation shall have ends sealed off with a vapor barrier coating. Insulation shall be covered with PVC or canvas jackets as specified in paragraph 15250-2.05. Refer to MICA Plate No. 36 for PVC jackets. Jacket shall be completely sealed.
2. Fittings, Connections, Flanges, and Valves: Insulation shall be provided with rigid PVC jackets specified in paragraph 15250-2.05. The ends of jackets shall be secured with PVC end caps.
Vapor barrier shall not be penetrated. Refer to MICA Plate No 12 (Fittings) and No. 15 (valves). Covers shall be secured with adhesive.

C. Exterior Insulation: Install continuous aluminum jackets per paragraph 15250-2.5 and seal all joints and seams with waterproof sealant. Install metal jacket with 2 inches overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 12 inches on center and at butt joints.

3.3 PIPING INSULATION

A. The insulation dimensional tolerances shall comply with the specified standards. Unless otherwise indicated, equipment insulation shall match thickness of attached piping. The minimum insulation thickness exclusive of jacket, and insulation type shall be as follows:

<table>
<thead>
<tr>
<th>Piping Service</th>
<th>Temperature °F</th>
<th>Pipe Sizes Inches</th>
<th>Insulation Type</th>
<th>Thickness Inches</th>
<th>Jacket Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water (Central Plant)</td>
<td>38-65</td>
<td>All</td>
<td>Cellular Glass - Rigid</td>
<td>2.0</td>
<td>PVC</td>
</tr>
<tr>
<td>Chilled Water (Exterior)</td>
<td>38-65</td>
<td>All</td>
<td>Cellular Glass - Rigid</td>
<td>2.0</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Heating Hot Water (Art Center)</td>
<td>120-200</td>
<td>All</td>
<td>Cellular Glass - Rigid</td>
<td>2.0</td>
<td>PVC</td>
</tr>
</tbody>
</table>

3.4 EQUIPMENT INSULATION SCHEDULE

A. Application to Equipment:

1. Cut, score, or miter insulation to fit contour of equipment.
2. Secure insulation to equipment with 1/2" x 0.015" galvanized steel bands or 16 gauge galvanized wire on 12 inch centers.
3. Weld pins or stick clips with washers may be used for flat surfaces and spaced 1'-6" apart.
4. Stagger joints and fill voids with fiberglass blanket insulation.
5. Cover joints in factory applied facing with 4 inch wide vapor barrier tape.
6. Insulate irregular non-straight surfaces using molded glass fiber fittings or fabricated mitered segments of pipe insulation securely wired in place.
7. Extend flange insulation minimum of two inches beyond bolt ends and fill voids with fiberglass insulation.

B. Equipment Finishes on Cold Surfaces (below 80 degrees F):

1. Where fabricated mitered segments of pipe insulation are used, cover with vapor barrier coating to seal joints and to make smooth finish.
2. Seal all joints as well as all penetrations in facing of insulation with 3-inch wide vapor barrier tape.
3. Apply a tack coat of lagging adhesive at rate of 2 gallons per 100 square feet, completely sealing all penetrations of insulation.
4. Embed canvas lagging in wet lagging adhesive. Lap all seams minimum of 2 inches and smooth out lagging to avoid all wrinkles.
C. Chilled Water Systems – Central Plant

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Bodies</td>
<td>2 inches</td>
</tr>
<tr>
<td>Chillers</td>
<td>Field insulate only per manufacturer's requirements</td>
</tr>
</tbody>
</table>

D. Hot Water Systems – Art Center

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Bodies</td>
<td>2 inches</td>
</tr>
<tr>
<td>Air Separator</td>
<td>2 inches</td>
</tr>
<tr>
<td>Expansion Tank</td>
<td>1 inch</td>
</tr>
<tr>
<td>Boilers</td>
<td>Field insulate only per manufacturer's requirements</td>
</tr>
</tbody>
</table>

END OF SECTION 15250
SECTION 15290 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SCOPE
A. This section specifies insulation used on ductwork.

1.2 QUALITY ASSURANCE
A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

   ASTM C553 Mineral Fiber Blanket and Felt Insulation.
   SMACNA DCS SMACNA Duct Construction Standards.
   UL 723 Surface Burning Characteristics of Building Materials.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with UL 723 and UL790.

C. Applicator: Company specializing in performing the work of this section with minimum three years experience.

D. Store insulation in original wrapping and protect from weather and construction traffic.

E. Protect insulation against dirt, water, chemical, and mechanical damage.

F. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

G. Maintain temperature during and after installation for minimum period of 24 hours.

1.3 SUBMITTALS
A. Refer to Section 15010 for additional requirements.

B. Submit:
   1. Product Data: Provide product description, list of materials and thickness for each service, and locations.
   2. Samples: Submit two samples of any representative size illustrating each insulation type.
1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate clearance requirements with duct installer for insulation application.

1.6 SCHEDULING

A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 - PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Manufacturer shall be Johns Manville Microlite all-service faced duct wrap or equal.

B. All ducts shall be insulated on the outside with flexible glass fiber blanket with a minimum installed R-Value of 8.0 and Type FSK facing.

C. Insulation: ASTM C553; flexible, noncombustible blanket.

1. Thermal conductivity or 'K-value': ASTM C518, 0.29 Btu-in/hr•ft2•ºF at 75ºF.
2. Maximum service temperature: 250ºF.
3. Maximum moisture absorption: <3% at 120ºF.
4. Density: 0.75 lb/cu ft.

D. Vapor Barrier Jacket

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Secure with pressure sensitive tape.

E. Vapor Barrier Tape

1. Manufacturers: Owens-Corning or equal (no known equal).
2. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

F. Tie Wire: Annealed steel, 16 gage.

2.2 GLASS FIBER DUCT LINER

A. Manufacturer shall be Johns Manville Permacote Linacoustic R-300 Rigid Fiber Coated Glass Liner or equal.
B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. Thermal conductivity or ‘K-value’: ASTM C518, 0.12 Btu-in/hr•ft²•ºF at 75°F.
   2. R-Value: 8.0
   3. Maximum service temperature: 250ºF.
   4. Density: 3.0 lb/cu ft.
   5. Maximum Velocity on Coated Air Side: 4,000 ft/min.

C. Liner Fasteners: Galvanized steel with press-on head conforming to SMACNA.

D. Adhesive:
   1. Manufacturer shall be Johns Manville, Owens-Corning or equal.
   2. Waterproof fire-retardant type conforming to ASC-A-7001C.

2.3 JACKET

A. Aluminum Jacket: ASTM B209
   1. Thickness: 0.020 inch sheet.
   2. Finish: Embossed.
   4. Fittings: 0.020 inch thick die shaped fitting covers with factory attached protective liner.
   5. Metal Jacket Bands: 1/2 inch wide; 0.010 inch thick aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify surfaces are smooth, dry, clean, and free from dust, debris, or other loose materials. Surfaces must be dry before the application of the insulation.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer’s instructions.

B. Deliver products to the job site in manufacturer’s original sealed containers with seals and labels intact. All materials shall be stored at job site, in an enclosed space, protected from excessive heat and cold, in accordance with material manufacturer’s instructions.

C. Insulated ductwork conveying air below ambient temperature:
   1. Provide insulation with vapor barrier jackets.
   2. Finish with tape and vapor barrier jacket.
   3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
   4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
D. External Duct Insulation Application:
   1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
   2. Secure insulation without vapor barrier with staples, tape, or wires.
   3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
   4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
   5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

E. Duct and Plenum Liner Application:
   1. Adhere insulation with adhesive for 100 percent coverage.
   2. Top and bottom pieces shall lap the side pieces and, in addition, shall be secured with galvanized pins and speed washers or cup-head pins maximum spacing shall conform to SMACNA DCS Figure 2-22.
   3. Pins and washers shall be flush with the surface of the duct liner, and breaks and punctures shall be sealed with adhesive specified in paragraph 15290-2.3-D.
   4. Exposed edges of the liner at duct ends and all joints where the lining will be subject to erosion shall be coated with a heavy brush-coat of fire-resistant adhesive and where velocity exceeds 4,000 FPM with a metal nosing to prevent delamination of the glass fibers.
   5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

F. The Contractor shall be responsible for providing and installing all protective covers, drops, and masking required to protect adjacent areas, equipment, utilities, parts, material, and other items from spills, mist, spray, etc.

G. The Contractor shall be responsible for the removal of and repairing any damage caused by cleaning chemicals, gravel, dust, coating materials, etc. The contractor shall also be responsible for damage caused by workers, equipment, etc.

3.3 TOLERANCE

A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.
### DUCTWORK INSULATION AND LINER SCHEDULE

<table>
<thead>
<tr>
<th>Service</th>
<th>Sizes (Inch)</th>
<th>Insulation Type</th>
<th>Thickness Inches</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply and Return Ductwork in Non-Conditioned Spaces</td>
<td>All</td>
<td>Glass Fiber Flexible</td>
<td>1-1/2</td>
<td>Vapor Barrier Finish</td>
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<tr>
<td>Supply and Return Lined Ductwork (Inside Clear Dimensions)</td>
<td>All</td>
<td>Liner</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Engine Exhaust Indoor and Outdoor</td>
<td>All</td>
<td>Cellular Glass - Rigid</td>
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<td>Aluminum Jacket</td>
</tr>
</tbody>
</table>

END OF SECTION 15290
SECTION 15430 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies backflow preventers, cleanouts, earthquake valves, floor drains, floor sinks, hose bibs, roof receptors, roof drains, roof overflow drains, trap primers, water hammer arrestors, access panels, gas regulators and gas totalizers.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANSI/ASSE 1011</td>
<td>Hose Connection Vacuum Breakers</td>
</tr>
<tr>
<td>ANSI A112.21.1</td>
<td>Floor Drains, Shower Drains</td>
</tr>
<tr>
<td>ANSI A112.21.2</td>
<td>Roof Drains</td>
</tr>
<tr>
<td>ANSI A112.36.2</td>
<td>Cleanouts.</td>
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<tr>
<td>ANSI/ASSE 1018</td>
<td>Trap Seal Primer Valves (Water Supply Fed.)</td>
</tr>
<tr>
<td>ANSI/ASME A112.21.1</td>
<td>Floor Drains.</td>
</tr>
<tr>
<td>IAPMO PS 31</td>
<td>Backflow Prevention Devices.</td>
</tr>
<tr>
<td>PDI WH-201</td>
<td>Water Hammer Arrestors.</td>
</tr>
</tbody>
</table>

B. Perform Work in accordance with California Plumbing Code.

C. Conform to Health Department requirements for installation of backflow prevention devices.

D. Provide certificate of compliance from authority having jurisdiction indicating approval of installation and testing of backflow prevention devices.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit the following:

1. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
2. Product Data: Provide component sizes, rough-in requirements, service sizes, materials, and finishes.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010.

B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
PART 2 - PRODUCTS

2.1 BACKFLOW PREVENTERS (BFP)
   A. Manufacturers shall be Watts Regulator Model 909-NRS, Wilkins, Febco, or equal.
   B. Unit shall be full stainless steel body with stainless steel internal parts, 4” size, and meet all FDA requirements.
   C. Provide Watts 909-AG-K air gap fitting.

2.2 CATCH BASIN (CB)
   A. Manufacturers shall be MIFAB Model F-1580-3-5-FLC, J.R. Smith, Zurn Industries, or equal
   B. Floor drain shall comply with ANSI A112.21.1.
   C. Provide DUCO cast iron body, sediment bucket, round adjustable grate, p-trap and trap primer connection.

2.3 CLEANOUTS (CO)
   A. Manufacturers shall be MIFAB, J.R. Smith, Zurn Industries, or equal
   B. Exterior Surfaced Areas (CO):
      1. Cleanout shall comply with ANSI A112.36.2.
      2. Provide line type with lacquered cast iron body and round epoxy coated gasketed cover.
   C. Exterior Unsurfaced Areas (COTG):
      1. Cleanout shall comply with ANSI A112.36.2.
      2. Provide line type with lacquered cast iron body and round epoxy coated gasketed cover.
   D. Interior Finished Floor Areas (FCO):
      1. Cleanout shall comply with ANSI A112.36.2.
      2. Provide cast nickel bronze, two piece body and adjustable nickel-bronze, round cover with gasket seal and bronze plug.
   E. Interior Finished Wall Areas (WCO):
      1. Cleanout shall comply with ANSI A112.36.2.
      2. Provide counter sunk cleanout brass plug in fitting. Chrome plated bronze deep cover with center screw.

2.4 EARTHQUAKE VALVE (EQV-1)
   A. Manufacturer shall be California Valve or equal.
B. Provide the following:

1. Seismic sensor gas shut off that shall be provided with 2 inch standard flanged openings.
2. Valve shall be fitted with one valves body built from bar stock aluminum (Type 6061) to a T6 condition milled on a CNC machine. To minimize the effects of falling debris damage, no die casting shall be used in the valve body design.
3. Valve design will not become more sensitive if the valve becomes off centered.
4. No springs or levers will be allowed.
5. Provide three O-rings made of Buna N compound and four silicone gaskets. The top center of the valve shall incorporate one glass circular leveler.
6. Valve must be warranted for no less than thirty years.
7. Valve will be provided with one reset key composed of one steel stud milled to 0.3125 inches/#18 thread and two black plastic knobs with one ball brass insert.
8. Valve must be installed by a state licensed certified contractor for earthquake valve installation.
9. Valve will be painted with gray enamel with an etched primer baked at 200 degrees F for two hours.
10. Valve shall be provided with four 0.25 inch FNPT openings to accommodate either a 0.25 inch plug or two male/female 0.25 inch all brass gas cocks. One gas cock will accommodate the provided pressure when valve needs to be reset.
11. Valve must carry the State of California Architect Certification (DSA #45R-113R), International Association of Plumbing Mechanical Officials Listing, Factory Mutual Approval, and Underwriter Laboratory Listing.
12. Maximum allowable working pressure will be 60 psig and tested to five times pressure rating.

2.5 FLOOR DRAIN (FD)

A. Manufacturers shall be MIFAB Model F-1100C-Z, J.R. Smith, Zurn Industries, or equal

B. Floor drain shall comply with ANSI A112.21.1.

C. Provide DUCO cast iron body, sediment bucket, round adjustable grate and trap primer connection.

2.6 FLOOR SINK (FS)

A. Manufacturers shall be MIFAB Model FS-1730-3, J.R. Smith, Zurn Industries, or equal

B. Floor sink shall be square cast iron body, enamel coated interior, aluminum dome strainer, nickel bronze frame, half grate and trap primer connection.

2.7 GAS FLOW METERS

A. Manufacturer shall be Romet, Equimeter, Smith Meter or equal.

B. Rotary type flow meter with digital counter, and aluminum case

C. Temperature and pressure compensation with internal corrosion resistant components.

D. Provide with flanged ends for 2,000 CFH or more, for gas working pressures, specific gravity, and volume flow indicated.
2.8 HOSE BIBBS (HB-1)
   A. Manufacturer shall be Acorn Model 8126-CP, MIFAB, Zurn Industries or equal.
   B. Hose bibb shall be cartridge operated hose valve with lockshield bonnet, removable key handle and vacuum breaker.
   C. Comply with ANSI/ASSE 1011.

2.9 HOSE BIBBS (HB-2)
   A. Manufacturer shall be Acorn Model 8121-CP, MIFAB, Zurn Industries or equal.
   B. Hose bibb shall be cartridge operated hose valve with lockshield bonnet, removable key handle and vacuum breaker.
   C. Comply with ANSI/ASSE 1011.

2.10 ROOF RECEPTOR (RR-1)
   A. Manufacturer shall be MIFAB Model R1100-RS-BU-W1-6, J.R. Smith, Zurn Industries, or equal.
   B. Roof receptor shall comply with ANSI A112.21.2M.
   C. Provide lacquered cast iron deep sump with 8” diameter anchor flange, 2” high cast iron external combined dam and waterproofing membrane clamp ring and internal dome strainer.

2.11 TRAP PRIMER (TP)
   A. Manufacturers shall be MIFAB Model M500 with M1-DU trap primer distribution unit, J.R. Smith, Zurn Industries, or equal
   B. ANSI/ASSE 1018; brass body, "O" ring seals, adjustable to line pressure and desired delivery amount.

2.12 WATER HAMMER ARRESTORS (WHA)
   A. Manufacturers shall be MIFAB Model WHB Alphabetical Series, J.R. Smith, Zurn Industries, or equal
   B. Water hammer arrestor shall be bellows type and comply with ANSI A112.26.1M.
   C. Size in accordance with PDI WH-201, precharged suitable for operation in temperature range -100 to 300°F and maximum 250 psig working pressure.
PART 3 - EXECUTION

3.1 PREPARATION
   A. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

3.2 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with Teflon based thread point compound. Ensure clearance at cleanout for rodding of drainage system.
   C. Install trap primers on all floor drains, floor sinks, trench drains, and industrial receptors. Provide 1/2" ball valve and union at each trap primer installation.
   D. Provide natural gas flow meter on gas services supplying equipment rated at 1,000,000 BTU or more.

END OF SECTION 15430
PART 1 - GENERAL

1.1 SCOPE

A. This section specifies emergency eye wash.
B. All plumbing fixtures shall comply with all the requirements of the latest edition of the CBC Section 1115B. Heights and location of all fixtures shall be according to the latest edition of the CBC Table 1115B-1. Fixture controls, where applicable, shall comply with the latest edition of CBC Section 1118B.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ANSI A112.19.5 Trim for Water-Closet Bowls, Tanks, and Urinals (Dimensional Standards)
- ANSI/ASME A112.6.1 Supports for Off-the-Floor Plumbing Fixtures for Public Use
- ANSI/ASME A112.18.1 Finished and Rough Brass Plumbing Fixture Fittings
- ANSI/ASME A112.19.2 Vitreous China Plumbing Fixtures
- ANSI/ARI 1010 Drinking Fountains and Self-Contained, Mechanically-Refrigerated Drinking-Water Coolers
- ANSI/ARI 1020 Application and Installation of Drinking Fountains and Drinking Water Coolers
- NFPA 70 National Electrical Code
- ANSI/ASSE 1016 Shower Control Valves Anti-Scald Type

B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

C. Verify that field measurements are as instructed by the manufacturer.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.
B. Provide:
   1. Provide three years warranty on all fixtures.
   2. Catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010.
PART 2 - PRODUCTS

2.1 EMERGENCY EYE WASH (EEW-1)

A. Manufacturer shall be Haws Model 7271, Bradley, Guardian or equal.

B. Unit shall be provided with the following features:
   1. Eye wash shall comply with ANSI Z358.1.
   2. Eye wash shall be free standing type with stainless steel eyewash bowl, with 2 ABS soft-flow anti-surge plastic heads complete with dust covers.
   3. Eyewash unit shall be provided with scald protection bleed valve, which shall release water through line when internal temperature rises above 100°F (38°C).
   4. Provide stainless steel push flag and foot pedal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

3.2 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

A. Installation of plumbing fixtures:
   1. Install each fixture at the exact height and location shown on drawings.
   2. Set fixtures, supplies, traps and trap outlets square with the wall, in line with fixture outlets without offsets, angles, or bends.
   3. Grout joint between fixture and wall or floor with silicone sealant to provide a smooth, even, and watertight seal.
   4. Make up watertight joints for drainage connections to fixtures in accordance with the Uniform Plumbing Code.
   5. Furnish fixtures complete with necessary trim and stops, chrome-plated brass, including tailpieces, traps and escutcheons.
   6. Connect to fixtures in accordance with code requirements except as exceeded herein or on the Drawings, and in no case, provide smaller than the supply stop size.
   7. Install in accordance with manufacturer's instructions.
   8. Install each fixture with a trap, easily removable for servicing and cleaning.
   9. Provide IAPMO approved stainless steel braided flexible supplies to fixtures with loose key stops, and escutcheons.
B. Verify that walls and floor finishes are fully prepared and ready for installation of fixtures.

C. Install components level and plumb. Install piping parallel or perpendicular to wall alignment.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Confirm location and size of fixtures and openings before rough-in and installation.

3.5 ADJUSTING

A. Adjust flow control valves for intended rates to fixtures without splashing, noise, or causing overflow of receptors.

3.6 CLEANING

A. Completion of work, clean plumbing fixtures and equipment.

3.7 PROTECTION OF FINISHED WORK

A. Seal drains so dirt and debris cannot enter and do not permit the use of fixtures during construction activities.

END OF SECTION 15440
SECTION 15515 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SCOPE

A. This section coil balancing valves, air vents, pressure reducing valve and pressure relief valves, air separator, expansion tank, strainer, suction diffuser.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ANSI B16.1 Pipe Flanges and Flanged Fittings.
- ASME Section VIII Boiler and Pressure Vessel Code; Rules for Construction of Pressure Vessels.

B. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Provide:

1. Manufacturer’s catalog data confirming conformance to specified design, material and equipment requirements.
2. Flow and calibration curves for balancing valves and suction diffuser.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Air Separator – Air and Dirt:

1. Manufacturer shall be Armstrong, Taco, Spirotherm, Bell & Gossett.
2. Provide with blow-down valve, skim valve and automatic air vent.
3. Air separator shall utilize stainless steel coalescing medium to aid in separation of air and dirt in the entrained water.
5. Tangential inlet and outlet flanged connections, and internal stainless steel air collector tube.
6. Provide factory installed mounting angles welded onto the air separator for hanging from the structure above.
7. Strainer is not required.
B. Automatic Air Vent Valve:
   1. Manufacturer shall be Armstrong, Bell & Gossett or equal.
   2. Air vent valve shall be the float operated, simple lever type, designed for 150 psig working pressure.
   3. Body and cover shall be cast iron, float shall be Type 316, stainless steel, seat shall be synthetic rubber, and other internal parts shall be Type 316 stainless steel.
   4. An integral check valve shall prevent leakage of air into the hydronic system.
   5. The connection size shall be 3/4” male pipe thread.

C. Coil Balancing Valve:
   1. Manufacturer shall be Griswold.
   2. Supply side piping package shall be:
      a. Griswold Model Isolator “S” or equal.
      b. Provide ball valve with Pete's plug for ½” through 2-1/2” sizes.
      c. Provide flanged connection with Pete's plug and butterfly valve for sizes 3” and above.
   3. Return side piping package shall be:
      a. Griswold Model Isolator “R” or equal.
      b. The water flow rate for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within 5% of the specified amount. The flow cartridge shall be removable from the Y-body housing without the use of special tools to provide access for flow cartridge change out, inspection and cleaning without breaking the main pipe.
      c. Each valve shall have two pressure/temperature ports.
      d. The internal flow limiting device shall be constructed of passivated stainless steel.
      e. The internal flow cartridge body shall be permanently marked with design flow rate and spring range.
      f. For ½” through 2-1/2” pipe sizes, assembly shall consist of a brass body Y-type body, integral brass body ball valve and ‘O’ ring type union. For large body up to 2-1/2”, use fixed threaded end connections.
      g. For 3” and larger flow control valves, provide Uniflange or wafer style class 150 connections, the long flange bolts and nuts shall be provided with each wafer style control valve.
      h. All valves shall be factory leak tested at 100 psi air under water.
   5. For stacked cooling coils, provide Griswold Quickset manual balancing valve to each coil connection.

D. Expansion Tank:
   1. Manufacturer shall be Armstrong, Bell & Gossett or equal.
   2. Pre-charged expansion tank shall be bladder type, body shall be constructed of carbon steel.
   3. Tank shall be closed, welded steel construction, pre-charged with replaceable heavy duty bladder.
   4. Tank shall be tested and stamped in accordance with Section 8D of ANSI/ASME Code for 125 psi working pressure rating.
   5. Tank shall be cleaned, prime coated, and supplied with floor mounting skirt; with tappings for installation of accessories.
   6. Provide pressure gage and charging valve connection, tank drain, seismic clips and pressure relief valve.
7. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

E. Manual Air Vent Valve:
   1. Manufacturer shall be Hoffman or equal.
   2. Manual air vent shall be a 1/2" ball valve, low projection type air vent for shallow height clearance installations. The valve shall be designed for 125 psig working pressure and maximum 240°F operating temperature.

F. Pressure Reducing Valve:
   1. Manufacturer shall be Bell and Gossett Model B Series or equal.
   2. Relief valve shall be bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

G. Pressure Relief Valve:
   1. Manufacturer shall be Bell and Gossett Model 790 Series or equal.
   2. Relief valve shall be bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

H. Strainer:
   1. Manufacturer shall be Mueller, Keckley or equal.
   2. Strainer be capable of operating with 125-psig working pressure, strainer shall be constructed of cast-iron body (ASTM A 126, Class B) with flanged ends, bolted cover, perforated stainless-steel basket, and bottom drain connection.
   3. Screen shall be constructed on maximum 40 mesh.

I. Suction Diffuser:
   1. Manufacturer shall be Armstrong, Bell & Gossett or equal.
   2. Pump suction diffuser shall be a combination strainer and pressure gradient equalizer constructed of cast iron body, cover and inlet vanes.
   3. Inlet connection shall be grooved-end, suitable for use with grooved-end couplings specified Section 15085. Inlet size shall be the full line size of the connected pump’s suction inlet size.
   4. The integral flanged outlet connection shall be provided for connection to the pump suction inlet.
   5. The suction diffuser shall consist of an angle type body with inlet vanes and a combination diffuser strainer orifice with 3/16” diameter openings. Strainer shall be stainless steel.
   6. The unit shall be equipped with a disposable fine mesh start-up strainer, which shall be removed after system start-up.
   7. A flanged and bolted cover shall be provided to allow removal of the strainer without disturbing the piping system connections.
   8. A strainer blow down opening and plug shall be provided in the suction diffuser body or cover.
   9. The unit shall be provided with an adjustable support foot.
3.1 INSTALLATION AND APPLICATION

A. Contractor shall provide automatic air vents at system high points where specified or indicated on the Drawings.

1. Air vent outlets shall be piped to the nearest drain, unless otherwise specified.
2. Provide automatic air vents with ball valve for isolation.

B. Contractor shall provide manual air vent valves at all accessible high points in the system where automatic air vent valves are not specified.

1. Air vents located in buildings shall be taken to the nearest floor sink with cock mounted 4 feet above the floor.
2. Provide with ball valve for isolation.

C. Contractor shall provide suction diffuser on the suction connection of each pump where specified.

1. The adjustable support foot shall be mounted on the pump base and adjustable to support the suction diffuser.
2. The start-up strainer shall be removed after system start-up is complete.

D. Balancing valves shall be installed with at least the minimum length, recommended by the manufacturer, of straight unrestricted pipe upstream and downstream of the specified valve location. Balancing valves shall not be used as isolation valves for leak proof shutoff.

E. Provide valved drain and hose connection on strainer blow down connection.

F. Provide relief valves on low pressure side of reducing valves, and expansion tanks.

G. 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.

H. Pipe relief valve outlet to nearest floor sink.

I. When one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

J. Pump discharge valves, suction diffusers and balancing valves on chilled water and heating hot water systems shall be insulated as specified in Section 15250.

K. Support expansion tanks and air separators inside building from floor or building structure. The site is located in an active seismic area (California Seismic Zone 4). The mounting and attachment of expansion tanks to floor or building structure shall be designed for Seismic Zone 4. Anchor calculations signed and stamped by a registered Structural engineer shall be submitted with the shop drawings for approval.

END OF SECTION 15515
SECTION 15535 – VERTICAL IN-LINE PUMPS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies epoxy painted, vertical in-line, split coupled centrifugal pumps.

B. Operating Requirements:

1. Pumps shall be identified by the equipment mark and designed for continuous duty under the operating conditions shown on the drawings. Each pump shall have duty points as scheduled, with minimum efficiencies as indicated. Alternate equipment must meet or exceed stated efficiencies with duty points having no negative tolerance on flow or head while maintaining and not exceeding the specified equipment's inlet /outlet nozzle velocity. Certified performance curves must be submitted with any requests for substitutions. These curves must indicate duration's as well as impacts on annual operating costs.

2. Motors shall be non-overloading at any point on the pump operating curve, unless otherwise approved by the College representative.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

AFBMA 9 Load Ratings and Fatigue Life for Ball Bearings.
ANSI/UL 778 Motor Operated Water Pumps.
HIS Hydraulic Institute Standards, 14th Edition

B. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum five years experience.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 15010.

1. Certified pump characteristic curve showing guaranteed performance including head, efficiency, BHP, and NPSH versus capacity for the impeller furnished, as well as expected performances for the maximum and minimum diameter impeller with which the pump can be fitted.

2. Submittal shall include all motor submittals required under Section 15170.

3. Complete parts list showing materials of construction pattern and drawings numbers.

4. External dimension sheet (outlines drawings).

5. Cross sectional assembly drawing.

6. Where mechanical seals are furnished the seal manufacturer’s detail assembly drawings and parts list.

8. Submit written certification for each piece of equipment that has been installed and aligned in accordance with manufacturer's requirements.
9. Epoxy painting data for pump and motor.

1.4 OPERATION AND MAINTENANCE DATA
A. Submit operation and maintenance data under provisions of Section 15010.
B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 EXTRA PARTS
A. Provide one extra set of seals for pumps under provisions of Section 15010.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS
A. Manufacturer shall be Armstrong Model 4300, Bell & Gossett, Paco or equal.

2.2 GENERAL CONSTRUCTION REQUIREMENTS
A. The pumps shall be radially split (split-coupled), single stage centrifugal type with rigid spacer type coupling.
B. Casing shall be bronze fitted casing with equal size suction and discharge flanges and having separate tapped flush line and pressure gauge connections.
C. Impeller shall be constructed of bronze and shall be dynamically balanced.
D. Pump shaft shall be stainless steel with lower carbon throttle bushing.
E. Coupling shall be rigid spacer type constructed of high tensile aluminum alloy. Coupling shall be split to allow removal from pump and motor shafts, leaving space between the shafts sufficient to replace all mechanical seal components without disturbing the pump or motor.
F. Mechanical seal shall be outside balanced type with carbon rotating face, ceramic stationary seat and Viton secondary seal.
G. The pump is to be fitted with a factory installed flush line. Provide in the flush line to the mechanical seal a 50-micron cartridge filter and sight flow indicator, to suit the working pressure encountered.
   1. For pumps with differential pressures exceeding 30 psig, provide the flush line to the mechanical seal a cyclone type separator, with sight flow indicator.
H. The squirrel cage induction type, TC or P-base, with enclosure as per installation and shall be connected to the pump through a high tensile aluminum, split type spacer coupling to permit servicing of the mechanical seal without disturbing pump, motor or electrical wiring.
I. Coupling shall be protected by a guard.

J. All pumps shall be fully epoxy painted.

K. Provide stanchion bracket for each pump. Coordinate height of stanchion bracket with contractor, standard height brackets may not be adequate.

2.3 MOTOR

A. The pump shall be driven by a totally enclosed fan cooled (TEFC) motor as specified in Section 15170.

B. Motor shall be of the speed and maximum horsepower as specified on the drawings. Pumps requiring larger horsepower shall not be acceptable.

C. Motor efficiency shall be as scheduled in Section 15170.

D. All motors shall be provided with shaft grounding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each pump shall be leveled, plumbed, aligned and wedged into position to fit connection piping. Installation procedures shall be as recommended by the pump manufacturer and HIS, and as required herein. Factory trained service technicians shall examine the installation prior to start-up and shall provide a written report that installation meets requirements by manufacturer.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Ensure pumps are lubricated and operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

D. Decrease from line size with long radius reducing elbows or 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 inches and over.

E. Provide drains for bases and seals, piped to and discharging into nearest floor sink or trench drain.

F. Mechanical contractor shall change the flush line 50-micron cartridge filter filters after the system has been flushed and on a regular basis until the pumps are turned over to the College.

3.2 TESTING

A. After completion of installation, each pumping unit shall be field tested to ensure compliance with the performance requirements as specified on the Drawings.

END OF SECTION 15535
SECTION 15545 - CHEMICAL WATER TREATMENT

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies:

1. Cleaning of new piping systems
2. Chemical feed equipment for open condenser water system.
3. Pot feeders and corrosion coupon racks for closed loop chilled and hot water system
4. First year startup chemical treatment program.

1.2 QUALITY ASSURANCE

A. The open condenser water system program shall consist of the services of a knowledgeable water treatment service engineer as selected and approved by the University’s Representative, selection of appropriate water treatment chemicals properly designed and installed chemical feed and control equipment, and appropriate test kits and reagents.

B. The chemical vendor as selected and approved by the University’s Representative shall provide written instructions stating point by point how the program is to be applied and how the system is controlled as well as what responses are appropriate in the event that any control parameter does not comply with this specification.

C. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for delivery to public sewage systems.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 15010:

1. Submit shop drawings indicating system schematics, equipment and skid locations, and component locations.
2. Submit MSD sheets on all chemicals.
3. Submit tanks sizes, weights, seismic support information, etc.
4. Submit manufacturer’s field reports.
5. Submit manufacturer’s installation instructions.
6. Submit reports indicating start-up of treatment systems are completed and operating properly.
7. Submit reports indicating analysis of system water after cleaning and after initial treatment (after 1st month of operation); subsequent reports are to be provided to the appropriate Owner personnel after each service visit.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 15010.

B. Include step by step instructions on test procedures including target concentrations.
1.5 MAINTENANCE SERVICE

A. Service and maintenance of treatment systems shall occur for one year from startup of system (from the point when there is a load on the system).

1.6 MAINTENANCE MATERIALS

A. Submit maintenance materials under provisions of Section 15010.

B. Provide sufficient chemicals and labor for maintaining a full service program during the first year warranty period.

1.7 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including heating hot water and chilled water, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.

2. Soluble Copper: Maintain a maximum value of 0.10 ppm.

3. Ammonia: Maintain a maximum value of 20 ppm.


5. Microbiological Limits: Maintain a maximum value of 10,000 organisms/ml total aerobic plate count.

D. Open hydronic systems, including condenser water, shall have the following water qualities:

1. pH: Maintain a value within 7.8 to 8.1.

2. Soluble Copper: Maintain a maximum value of 0.20 ppm.

3. Microbiological Limits: Maintain a maximum value of 100,000 organisms/ml total aerobic plate count.

4. Polymer Testable: Maintain a minimum value within 10 to 40.

E. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.

2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.

3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.
PART 2 - PRODUCTS

2.1 ACCEPTABLE SUPPLIERS

A. Chemical water treatment supplier shall be approved by the University’s Representative.

2.2 CHEMICAL WATER TREATMENT SYSTEM

A. The water treatment contractor shall provide all required services, chemicals, equipment, testing equipment, and guarantees for a complete and operational system.

B. The water treatment contractor shall visit and test all cooling systems, at least once a month for one year from startup of system (from the point when there is a load on the system).

C. A report of the existing water conditions and suggested corrective measures will be submitted at the completion of each visit.

D. Should scale or biological growths, ("fouling") occur in any system, the water treatment contractor shall provide all labor and chemicals to bring the system to an acceptable level at no additional cost to the Owner, during normal working hours.

E. Log sheets and instructions shall be provided for the University’s Representative and personnel.

F. Corrosion coupons shall be installed in each treated water system with representative metals, monitored by the water treatment contractor every 90 days with the results included in a written report.

G. The water treatment contractor shall supervise the following:

1. The installation of all water treatment equipment.
2. The cleaning of the open and closed systems with a written certification of cleanliness upon completion.

H. The chemical water treatment contractor shall be fully responsible to coordinate all mechanical and plumbing requirements for a complete and operational chemical water treatment system with both the mechanical and plumbing contractor.

2.3 CHEMICALS

A. The water treatment contractor shall provide all necessary and proper chemicals to operate the systems for a period of one year from initial operation.

B. The following shall be included:

1. Cleaning chemicals, in liquid form, for the cleaning of open and closed systems.
2. Sulfuric acid shall be used unless sulfate content of the make up water in the area does not permit its practical usage, in which case, the water treatment contractor will suggest an alternative acid. A pH between 7.8-8.1 will be maintained.
3. A corrosion inhibitor with sequestering properties will be used in all tower systems, both acid and non acid.
4. At least two different EPA approved biocides shall be used in the tower system.
5. Closed systems other than aerated systems will be treated with a borate nitrite compound. The following residuals shall be maintained:
   a. 700 - 1200 ppm nitrite in chilled water systems.
   b. 1000 - 1500 ppm nitrite in hot water heating systems.
   c. A proper biocide shall be added.

2.4 EQUIPMENT (ALL ELECTRICAL MUST BE UL APPROVED)

A. Open Cooling Tower:
   1. Provide required quantity of pH/conductivity/dual biocide controller (minimum one) with lockout feed and bleed during biocide addition and water meter reading capability.
   2. Provide required quantity of totalizing flow meter (minimum one).
   3. Provide required quantity of chemical metering pumps (minimum four) with 1.0 GPH at 110 psi and at least one with a four function head with positive anti-syphon, back pressure, priming aid-line pressure release and pressure relief and stroke frequency and stroke length knobs capable of feeding concentrated sulfuric acid.
   4. Provide required quantity of double containment units (minimum three).
      a. Provide minimum one 120 gallon inhibitor tank.
      b. Provide minimum one 65 gallon biocide tank.
      c. Chemical water treatment contractor shall be responsible to provide tanks with seismic support and secure to concrete pad.
   5. Provide required quantity of 1 inch metal solenoid bleed valve (minimum one).
   6. Provide required quantity of stainless corporation stop (minimum one).
   7. Provide required quantity of 2 inch contacting water meter (minimum one).
   8. Provide required quantity of bromine feeder with at least 75 pound capacity and an electrical 3/4 inch metal solenoid valve (minimum one). Manufacturer shall be J.L. Wingert FRP-DB 12 Gallon tank or equal.
   9. Provide required quantity of corrosion coupon rack (minimum one) with minimum four stations capable of 5 GPM flow control.

B. Closed Systems:
   1. For closed chilled water system, provide one 5 gallon pot feeder and corrosion coupon rack with 4 stations and 5 GPM flow control. Manufacturer shall be J.L. Wingert FRP-DB 5 Gallon tank or equal.
   2. For closed heating hot water system, provide one 5 gallon pot feeder with metal corrosion coupon rack with 4 stations and 5 GPM flow control. Manufacturer shall be J.L. Wingert FRP-DB 5 Gallon tank or equal.

2.5 TESTING EQUIPMENT

A. The contractor shall provide the following as a minimum:
   1. One hand held 0-5000 umhos conductivity meter - Myron 512M-5 with no substitution.
   2. One pH test kit.
   3. One tower inhibitor test kit.
   4. One hardness test kit.
   5. One chlorides test kit.
6. One alkalinity test kit.
7. One corrosion inhibitor test kit for the closed systems.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 PREPARATION AND CLEANING

A. The systems shall be precleaned prior to using.

B. The system cleaner shall be re-circulated for not less than six (6) hours after which the system shall be rapidly dumped with re-circulating pumps operating to provide maximum practical motion and whenever possible, with simultaneously adding or chasing with rinse water. It is important that make-up water rate exceed water discharge rate. In either case, the system shall be flushed until neutral to phenolphthalein, contain the same pH and TDS as the clean flushing water and free from suspended material and color.

C. After flushing, all strainers shall be removed and cleaned. If the system contains a significant level of suspended solids, recirculating pump seal replacement may be required as requested by the project engineer as recommended by the water treatment field service application specialist. These functions will be the responsibility of the mechanical contractor with supervision of the water treatment application specialist.

D. Be sure that all coils are open and that cleaning solution is re-circulating through them and totally flushed from the system. These functions will be the responsibility of the mechanical contractor with supervision of the water treatment application specialist.

E. The systems shall have 1 ppm or less iron content when considered clean. If iron content is greater than 1 ppm, the add corrosion inhibitor immediately.

F. Place all valves in open position during the cleaning procedure. Place all valves in open position during the cleaning procedure for the loop piping except those isolating the cooling tower from the loop.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 15545
SECTION 15548 - COOLING TOWER CLEANING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. This section specifies a high efficiency single skid mounted cooling tower cleaning system.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 15010:

1. Submit shop drawings indicating system schematics, equipment locations, and component locations.
2. Submit manufacturer's installation instructions.
3. Submit a minimum of three references, which have been using the manufacturer’s filtration system for the past three years. The cooling towers shall be of equal or larger size than the cooling towers for this project.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 15010.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. Manufacturer shall be Lakos TCI Series or equal.

2.2 PRODUCT REQUIREMENTS

A. Provide a completely assembled package supplied for the isolated recirculation and particle separation/filtration of the fluid in the cooling tower basin in order to prevent troublesome accumulation of solids in the tower basin. Flow through the separator package shall be continuous, without interruption for the periodic evacuation of separated solids.

B. Efficiency:

1. 98% efficiency at 40 microns for solids with a specific gravity of 2.6
2. 90% efficiency at 5 microns

C. Placement of the separator package's inlet and outlet within the basin shall be strategically determined and supplemented where necessary with specific flow enhancement/agitation devices. Each agitation device shall be capable of increasing its input flow, at 20 psi or more, to six times greater output flow without abrasive wear to the agitator, thereby providing the proper directed turbulence to prevent
troublesome solids accumulation and induce separable solids to the separator package's pump suction. Required submergence shall be as little as 2-3 inches. Unit shall be made of polypropylene construction.

2.3 OPERATION AND COMPONENTS

A. The separator package shall provide for initial pre-straining prior to pump suction, followed by direct pumping through a specific centrifugal-action solids-from-liquid separator and immediate return of flow to the agitator. Separated solids shall be continuously bled from the separator's collection chamber into the package's integral solids recovery vessel and solids collection bag. Excess liquid shall pass through the bag and return to system flow via piping connected to the package's pump suction line. Alternatively, the separated solids may be purged periodically to desired disposal with an automatic purge valve.

B. Strainer:
   2. The minimum mesh rating shall be 9/32”.
   3. The strainer basket shall be stainless steel.

C. Pump:
   1. End-suction, close coupled, single stage pump with TEFC motor.
   2. Cast iron housing with iron impeller with bronze shaft sleeve and BUNA-N mechanical shaft seal.
   3. Refer to mechanical drawings for performance requirements.

D. Separator shall be centrifugal-action design, incorporating a true tangential inlet and mutually tangential Swirllex internal accelerating slots, employed to promote the proper velocity necessary for the removal of the separable solids. The internal accelerating slots shall be spiral-cut for optimum flow transfer, laminar action and particle influence into the separation barrel. The separator's internal vortex shall allow this process to occur without wear to the accelerating slots.

E. Separated particle matter shall spiral downward along the perimeter of the inner separation barrel, in a manner which does not promote wear of the separation barrel, and into the solids collection chamber, located below the vortex deflector plate.

D. To insure maximum particle removal characteristics at flow rates of 400 U.S. gpm or greater, the separator shall incorporate a vortex-induced pressure relief line, drawing specific pressure and fluid from the separator's extended solids collection chamber via the outlet flow's vortex/venturi effect, thereby efficiently encouraging solids into the collection chamber.

E. System fluid shall exit the separator by following the center vortex in the separation barrel and spiral upward to the separator outlet.

F. Solids collection vessel housing shall be 304 stainless steel with stainless steel basket and coated carbon steel lid with air pressure relief valve. Furnish with 25-micron fiberfelt solids collection bag. Flow control orifice shall be included. Solids capacity shall be 360 cubic inches.

G. An Indicator Package, sensing pressure differential through the solids recovery vessel, shall identify when the internal bag requires cleaning/replacement. Provide indicator gauge with a dry electric contact in order to operate a light or audible signal when bag servicing is required.

H. Piping shall be schedule 40 galvanized carbon steel with reinforced rubber hose to solids recovery vessel.

I. Electrical control shall be IEC starter with overload module. Provide with HOA selector switch, NEMA-4x enclosure, re-set/disconnect/trip switch, 120 volt, single phase control voltage.
J. Power requirement shall be as indicated on the mechanical drawings.

K. Provide ball valves on purge line for isolation of solids-handling/purging equipment.

L. Provide inlet/outlet valve kit. Butterfly valve on inlet and outlet.

M. Skid plate shall be stainless steel, 3/16” minimum thickness.

N. Maximum working pressure shall be 125 psi.

O. Maximum operating temperature shall be 100 degrees F.

P. Package system shall be rated for 400 gpm. Inlet connection shall be 6” flanged and outlet connection shall be 4” grooved. Pump horsepower shall be 15.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Place vessels as shown in installation drawing and level. Use manifold as guide for spacing. Install upper and lower manifolds as per manufacturer's instructions. Install piping between manifold and pumps.

B. Anchor control panel to wall. Connect control tubing to valves and manifolds according to manufacturer’s instructions.

C. Connect electrical power to control panel and control to pumps according to local electrical codes and wiring diagram supplied by manufacturer.

D. Install media according to manufacturer’s instructions.

3.2 STARTUP AND TESTING

A. Startup by factory-authorized agent shall be provided.

END OF SECTION 15548
SECTION 15625 – CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SCOPE:

A. This section specifies two packaged electric motor-driven centrifugal water chillers.

B. General Requirements:

1. The efficiencies and the performance as specified on the drawings shall be met by the equipment manufacturer.
2. The chiller units shall be installed, serviced, and started-up by a refrigeration organization and has minimum 5 years experience in servicing centrifugal chillers of the specified capacity.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those listed documents, the requirements of this section shall prevail.

- ANSI S1.13 Methods for the Measurement of Sound Pressure Levels.
- ARI 550 Centrifugal or Rotary Screw Water - Chilling Packages.
- ARI 575 Method of Measuring Machinery Sound within Equipment Rooms

B. Regulatory Requirements:

1. ASME rated unfired pressure vessels.
2. NEMA.
3. UL or ETL.

C. Testing Requirements:

1. Leak Testing and Testing for Proper Operation: The chiller shall be leak tested at 1-1/2 times working pressure. The chiller unit shall be tested for proper operation prior to the shipment of the equipment to the site.
2. Operational Acceptance Testing:

   a. The objective of these tests shall be to demonstrate that the chillers and accessories are ready for final operation.
   b. All system elements shall be checked to verify that they have been installed properly and that all terminations have been made correctly.
   c. All discrete elements and systems shall have their set points adjusted and shall be checked for proper operation (e.g., interlock functions, contact closure on rising/falling process variable, etc.).
   d. All continuous elements and systems shall have three-point calibrations performed. All controller-tuning constants shall be adjusted to preliminary settings.
The Contractor shall coordinate the mechanical work (Division 15) and the electrical work (Division 16) with the supplier of the chiller to ensure a complete and operable chiller system.

For convenience, general areas of responsibility are outlined here. This does not relieve the Contractor of his overall responsibility for coordinating the work.

E. Division 15 Responsibilities:

1. Provide a complete and operable chiller control system including wiring, conduit, and ancillary devices for all low voltage power requirements, as required.
2. Provide piping to chiller differential pressure switch for evaporator flow status remote from the chiller.
3. Furnish isolation pads with chiller.

F. Division 16 Responsibilities:

1. Provide single point 460 V power to chiller.

G. Warranty: Provide full one year warranty on the unit, which includes parts, refrigerant, oil and labor.

1.3 SUBMITTALS

A. The following information shall be provided in accordance with Section 15010:

1. Shop drawings.
2. Performance documentation at full load conditions verifying compliance with these specifications. Parameters shall include temperatures, pressures, and flow rates for waterside of pressure vessels, temperature and pressures on the refrigerant side of all pressure vessels, and safety tests. Provide kW draw versus load and chiller KW/ton.
3. Construction details and materials of construction.
4. Control panel details and interface with the energy management system.
5. Electrical wiring and control diagrams.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturer shall be Trane CVHF or equal.

2.2 MANUFACTURED UNITS

A. Factory assembled, single piece, liquid chillers shall consist of compressor, motor, unit mounted motor starter/variable speed drive, cooler, condenser, interstage flash economizer or sub cooler, initial oil and refrigerant operating charges, electronic microprocessor control system with EMS interface capability, and documentation required prior to start-up. Single point power connection shall be required.
2.3 COMPONENTS

A. Compressor and Motor:

1. Guide vanes shall be modulating variable inlet type vanes for each compressor stage controlled by externally mounted operator responding to refrigeration load on evaporator.
2. Impellers shall be fully shrouded and shall be fabricated from high strength cast aluminum alloy.
3. Drive shall be directly mounted on the motor shaft. Drive shall be statically and dynamically balanced and tested. Vibration shall not exceed 0.14 inches per second on motor housing.
4. Provide a separate cast iron volute for each impeller.
5. Motor:
   a. Compressor motors shall be of the single speed, nonreversing, and squirrel cage induction type suitable for 480 volts.
   b. Motors design speed shall be 3,600 rpm at 60 Hz.
   c. Hermetic motors shall be suitable for operation in a refrigerant atmosphere and shall be cooled by atomized subcooled refrigerant in contact with the motor windings.
   d. Motor stator shall be arranged for service or removal with only minor compressor disassembly and without breaking of main refrigerant piping connections.
   e. Full load operation of the motor shall not exceed nameplate rating.
   f. Lubrication: Provide a positive displacement submerged oil pump to provide oil to points requiring lubrication. Provide a sump heater to maintain oil temperature. Oil pump and sump heater to be powered from starter control power transformer.
   g. Provide variable speed drive. See Paragraph 2.4 F below.

B. Evaporator and Condenser:

1. Evaporator and condenser shall be in separate shells. Heat exchangers shall be fabricated with high performance copper tubing, steel shell and tube sheets and fabricated steel water boxes.
2. Tubing shall be copper, high-efficiency type, with integral internal and external fins. Tubes shall be nominal 3/4" OD with minimum wall thickness of 0.028" measured at the root of the fin. Tubes shall be rolled into tube sheets and expanded into support sheets, and shall be individually replaceable. End sheets shall be double grooved. Intermediate tube support sheet spacing shall not exceed 42".
3. Nozzle connections shall be designed for 150-psig maximum working pressure, unless otherwise noted. Nozzles shall be grooved end type.
4. Both condenser and evaporator display an ASME nameplate, which shows pressure, and temperature data and the "U" stamp for ASME Section VIII. Div. I on medium pressure machines.
5. Standard water boxes shall have vents, drains and covers to permit tube cleaning within the space shown on the drawings. Suitable tappings shall be provided in water boxes and nozzles for control sensors, gauges and thermometers. Marine water boxes are not required.
6. Tubes shall be removable from either end of the heat exchanger without affecting strength and durability of the tube sheet and without causing leakage in adjacent tubes.
7. Chiller manufacturer shall provide factory installed unit mounted gantrys (Davits) for both evaporator and condenser shells for removal of water boxes.

2.4 ACCESSORIES

A. Insulation:

1. The evaporator shell, suction elbow and the cooler water box covers, compressor motor, purge chamber and miscellaneous piping shall be factory insulated by the chiller manufacturer.
2. Insulation shall be minimum 3/4" thick and shall comply with Section 15250.
B. Vibration Isolation: Contractor shall furnish support plates and neoprene isolator pads for mounting equipment on a level concrete pad.

C. Controls:

   1. Control system shall be microprocessor based and fully automatic.
   2. Start-up and shutdown shall be manual or automatic. When start-up and shutdown are automatic, external signal is required (i.e., time clock).
   3. Capacity control shall be by integrated variable inlet guide vanes and compressor speed control. Load modulation shall be from 100% to 10% of full load under normal ARI conditions without the use of hot gas bypass.
   4. Refrigerant flow control shall be accomplished through the use of an orifice metering device or thermal expansion valve, to maintain optimum refrigerant levels under all loads or lift conditions.
   5. Factory furnished controls shall be pre-piped and pre-wired with connections to a terminal strip for interlock with other equipment.
   6. Oil pump shall be energized prior to chiller motor startup and shall have delayed action stopping to ensure that oil pressure is provided during machine coast-down.
   7. Microprocessor system shall include a programmed sequence to meet pre-lube and post-lube, pre-flow and post-flow needs prior to machine start-up during coast down after machine stops. The system shall assure a smooth pull down of loop temperature to prevent any power demand spikes. After shutdown, system must indicate time remaining until restart.
   8. Provide variable flow compensation capability such that chillers may operate in variable primary chilled water mode while using variable speed drive. All chillers applied in a variable evaporator flow shall be able to withstand a chilled water flow rate-of-change of 25 percent per minute while maintaining plus or minus two (+/-2) degrees of design supply chilled water temperature and 50 percent per minute at any load above the compressor minimum without cycling off on low load (low leaving water temperature) or evaporator refrigerant temperature limit.
   9. Provide refrigerant monitor input.

D. Safeties:

   1. Unit shall automatically shutdown upon tripping of any of the following-listed safety devices. Each of these devices shall require manual reset and cause an alarm indication.
      
      a. Motor over-current
      b. Over voltage
      c. Under voltage
      d. Low refrigerant temperature
      e. High condenser pressure
      f. High motor temperature
      g. High compressor discharge temperature
      h. Low oil pressure
      i. Phase loss
   
   2. Controls shall provide override condition to automatically reduce load on chiller in the event of high motor temperature or low refrigerant temperature and shall cause a pre-alarm indication. If either condition persists, the safeties shall then shut down the machine.
   3. Controls shall provide low chilled water temperature shutdown with automatic recycling to provide freeze protection at low load.
   4. Microprocessor system shall prevent machine re-start until a safe, preset time period has elapsed.
   5. Safety relief valves shall be installed on the chiller and pump out system for medium pressure machines. Rupture disks shall be installed on the chiller and pump out system for low-pressure machines.
E. Diagnostics:

1. Diagnostic display module shall be capable of indicating a safety lockout condition through the display of a two line clear language display. All of the devices listed in paragraph 2a above, shall be covered by the diagnostic display. Shutdown of any device shall provide a flashing display of first out indication.

2. A record of the last 3 failure modes (machine shutdowns) shall be stored in the memory of the diagnostics system for manual recall by an operator.

3. Diagnostic display module, in conjunction with the microprocessor control system, shall be capable of displaying the status of all devices to verify operation of all switches, thermistors, potentiometers, motors, etc., prior to machine start-up.

4. Indication of elapsed time, compressor motor amps, power-on, pre-alarm and alarm conditions shall be provided.

F. Chillers and EMS Interface:

1. Chiller manufacturer shall provide the one interface panel for both the chillers for the connections to the Energy Management System (EMS).

2. As a minimum the interface panel will perform and pass back to the existing controls system the following functions:

   a. Leaving chilled water temperature.
   b. Entering chilled water temperature.
   c. Leaving condenser water temperature.
   d. Entering condenser water temperature.
   e. Percent RLA.
   f. Evaporator refrigerant pressure.
   g. Condenser refrigerant pressure.
   h. Compressor discharge refrigerant temperature.
   i. Evaporator refrigerant temperature.
   j. Condenser refrigerant temperature.
   k. Chiller status.
   l. Condenser water flow status.
   m. Chiller water flow status.
   o. Auto reset alarm (diagnostic).
   p. Unit mounted control panel communications state.
   q. Chiller enable/disable.
   r. Chilled water set point.
   s. Current demand limit set point.
   t. Kilowatt Measurement.
   u. Kilowatt Hour Measurement.

G. Flow Switch:

1. Chiller manufacturer shall provide water flow safety switch (differential pressure type) in the chilled water piping to prevent cooler freeze-up under low or no flow conditions.

2. Chiller manufacturer shall provide water flow safety switch (differential pressure type) in the condenser water piping to assure condenser water flow during chiller operation.

3. Compressor shall shut down under low or no-flow conditions.

4. Flow switches shall be wired to the control panel.
H. Sound Level:

1. Sound level shall not exceed 85 dBA at full load when measured in a hemispheric free field per ARI 575 and ANSI S1.13.
2. Suitable sound attenuation provisions shall be taken to meet this requirement.
3. Any sound attenuation shall be easily removable for disassembly of the motor-compressor.

I. Starters:

1. Provide a unit mounted, factory wired, and tested 480 volt variable frequency drive starter (VFD) for each chiller with all instrument transformers, kW demand and consumption measuring transducers, and all protective devices and control components.
2. Drive shall be closed loop, liquid cooled, microprocessor-based PWM design.
3. Drive shall be both voltage and current-regulated.
4. Output power devices shall be IGBT transistors.
   a. Provide NEMA 1 ventilated enclosure with padlockable door-mounted circuit breaker/shunt trip and AIC rating of 65,000 amps. Starter package shall be UL/CUL listed. Drive shall be rated for 480/60/3 input power with a drive overload capability of 100% continuous to 150% for five seconds.
   b. Motor thermal overload protection 102% continuous, 140% for 1.5 seconds, 108% for 60 seconds. Provide VFD and motor protection from the following faults: output line-to-line and line-to-ground short circuit protection and line dip ride through; phase loss at VFD input; and over-voltage, under-voltage, overtemperature, phase reversal/imbalance.
   c. Minimum efficiency of 97% at rated load and 60 hertz. Adjustable frequency from 38 to 60 hertz.
   d. Soft start, linear acceleration, coast to stop.
   e. Control circuit voltages are physically and electrically isolated from power circuit voltage.
   f. Drive can be started without motor connected.
   g. VFD shall be designed to interface with chiller controls and allow for the operating ranges and specific characteristics of the chiller. VFD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain chilled water setpoint. Surge avoidance logic shall be in place.
   h. Compliance to IEE 519-1992 guidelines: The VFD design shall include as standard integrated active rectification control to limit total current distortion (TDD) at the VFD to less than 5-percent as measured at the VFD.

J. Pressure Gages:

1. Provide individual dial type pressure gages to indicate the following if the following is not accessible in plain English on the front of the chiller control panel:
   a. Evaporator refrigerant pressure.
   b. Condenser refrigerant pressure.
   c. Low oil sump temperature.
   d. High oil supplies temperature.

K. Switches:

1. Provide individual panel mounted switches for:
   a. Standby/reset-auto/remote control.
   b. On Off pilot light.
   c. Start-stop button.
d. Compressor indicator light.
e. Oil pump on-auto control.

L. Load Limit Control:
1. Provide load limit control designed to unload the compressor if the condenser water temperature is too high.

M. Davits:
1. Chiller manufacturer shall provide factory installed unit mounted davits for both evaporator and condenser shells for removal of standard water boxes.

PART 3 - EXECUTION

3.1 INSTALLATION BY CONTRACTOR

A. Install chiller on the vibration isolation on concrete equipment pad and make piping and conduit connections with Victaulic couplings or as recommended by the chiller manufacturer. Make provisions for removing and replacement of piping when required providing access for cleaning of condenser and evaporator tubes.

B. Install differential pressure switches and associated conduit and wiring. Install differential pressure switch between chilled water return and supply piping. Install differential pressure switch between condenser water return and supply piping. Switches shall make contact when flow is established.

C. Install necessary piping wells.

D. Pipe relief valves with limiting devices per manufacturer’s recommendations to vent outside building.

E. Insulate all low temperature surfaces, including heads.

F. Install 1/2 inch supply and return connections from oil cooler to chilled water supply as recommended by equipment manufacturer. Provide ball valves for oil cooler isolation.

G. Install drain and vent connections as required by equipment manufacturer and local codes.

3.2 ADJUSTMENT

A. After installation is complete, the Contractor shall arrange for start-up with factory-trained field technicians.

B. Provide the services of factory-trained field technicians to start up chillers, make adjustments, prove and record stages of operation and adjust control sequences and provide labor warranty.

C. Factory-trained field technicians shall be employed by a factory-authorized service organization located no more than 100 miles from project site. Maximum response time for service shall be two hours.
3.3 DEMONSTRATION

A. Provide factory-trained field technician to instruct the University on the operation and maintenance of the chillers.

B. Not less than 8 hours of training shall be provided to the University’s personnel.

3.4 MANUFACTURER'S FIELD SERVICES

A. Start-Up:

1. Manufacturer shall provide a factory-trained representative employed by the chiller manufacturer to perform the following services. Start-up supervision only, of Contractor personnel, will not be acceptable.

   a. Leak test
   b. Refrigerant pressure test
   c. Dehydrate
   d. Refrigerant charge chiller

2. After the above services have been performed, the same factory trained representative shall be available for a sufficient length of time, but not less than one (1) working day to instruct The University’s personnel in the proper operation and maintenance of the chiller.

3. Contractor shall supply to The University (6) copies of the following literature as furnished by the manufacturer prior to start-up:

   a. Installation drawings
   b. Wiring diagrams
   c. Installation instructions
   d. Start-up instructions
   e. Operation and maintenance instructions

END OF SECTION 15625
SECTION 15635 – REFRIGERANT MONITORING SYSTEM

PART 1 - GENERAL

1.1 SCOPE:
   A. This section specifies refrigerant monitoring system and associated alarms.

1.2 QUALITY ASSURANCE
   A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those listed documents, the requirements of this section shall prevail.
      

1.3 SUBMITTALS
   A. Refer to Section 15010 for additional requirements.
   B. The following information shall be provided:
      1. Product Data: Include mounting details and service requirements and compliance with authorized Federal agency.
      2. Shop Drawings: For each type of refrigerant monitor; include refrigerant ppm range, temperature range, alarm outputs, readout range, furnished specialties, installation requirements, and power consumption.
      4. Coordination Drawings: Include machinery room layout showing location of monitoring devices in relation to refrigerant equipment.
      5. Product Certificates: For monitoring devices, signed by product manufacturer.
      6. Operation and Maintenance Data: For refrigerant monitoring equipment to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURER
   A. Manufacturer shall be Vulcain or equal.

2.2 FUNCTIONAL DESCRIPTION OF REFRIGERANT MONITORING SYSTEM
   A. On leak detection by refrigerant sensor(s), the system shall perform the following:
      1. Activate machinery room ventilation.
      2. Activate audio and visual alarm inside and outside machinery room.

2.3 REFRIGERANT MONITOR

A. Description:

1. Ceramic metal-oxide semiconductor (CMOS) or infrared (IR) sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.
2. Refrigerant monitor shall be factory tested, certified and calibrated.

B. Performance Requirements

1. Refrigerant to Be Monitored: Hydrofluorocarbon or HFC-123
2. Refrigerant Concentration: 10 Parts per million (10 ppm or comply with requirements for actual refrigerant used)
3. Accuracy: 0-300 ppm R123; plus or minus 10 percent of reading
4. Linearity: 100 to 1000 ppm; plus or minus 2 percent of full scale
5. Sensitivity: 1 ppm
6. Resolution: 1 ppm
7. Operating Temperature: 41 to 104 deg F
8. Response Time: 90 percent of a step change in 4 minutes
9. Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range

C. Operating Requirements

1. Maximum Power Input: 120-V ac; 60 Hz, 30 W
2. Alarm Relays: 3 relays at 5- to 8-A resistive load
3. Alarm Set Points: Displayed on front of meter
4. Audible Output: As indicated on drawings
5. Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing
6. Serial Output Type: RS 232

D. Sensor Configuration

1. CMOS sensor
2. Single-sensing channel
3. Expandable to 6 channels

E. Display

1. Ten character, alphanumeric, vacuum-fluorescent indicating lights for each alarm set point
2. Standard alarm
3. Acknowledge switch and test switch mounted on front panel
4. Alarm status LEDs and service fault LEDs
5. Enclosure shall be NEMA 250, type as required for ambient condition

F. Alarm Output

1. Indicating light flashes and horn sounds
2. Unit-mounting device with single-light beacon
3. Field-adjustable alarm set points
2.4 REFRIGERANT GAS SENSOR
   A. Refrigerant gas will enter the infrared gas detection chamber according to the diffusion principle. The gas sensor will have resolution levels of 1 ppm with a standard range of 0-1000 ppm. Temperature and relative humidity variations will have no effect on the unit’s accuracy. Sensor shall be installed 1’-0” above finished floor.
   B. Sensor will be capable of operating within relative humidity ranges of 5-95% and temperature ranges of 32º F-100 º F.
   C. Unit will be equipped with a NEMA 4X Polycarbonate-ABS impact resistant housing.
   D. Sensor Alarm Levels
      1. First alarm setpoint at 250 ppm
      2. Second alarm setpoint at 350 ppm

2.5 CONTROL CABLE
   A. Electronic and fiber-optic cable for control wiring.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine chiller layout for proper location of monitoring device.
   B. Verify refrigerant contained in chiller(s) to ensure compatibility of refrigerant monitor.
   C. Examine machinery room ventilation system to verify its operation with refrigerant monitor(s).

3.2 INSTALLATION
   A. Install refrigerant monitoring equipment level and plumb.
   B. Install equipment, devices and wiring, according to manufacturer's written instructions. Provide all of the wiring as required for a complete and functional system.
   C. Install labels and nameplates to identify monitoring devices and components according to Division 15 Section "Mechanical Identification."
   D. Install building wire and cable according to Division 16.

3.3 FIELD QUALITY CONTROL
   A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. Test Reports: Prepare a written report to record the following:
   a. Test procedures used
   b. Test results that comply with requirements
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING
A. Adjust alarm set points.
B. Test all of the sensors with simulating the sensors operation and calibrate the sensors.
C. Test the alarm devices.
D. Test all of the system functions.
E. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 COMMISSIONING
A. Provide the services of a factory-authorized service representative to provide startup service and to demonstrate and train University’s maintenance personnel as specified.
B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION
A. Provide services of supplier's technical representative for half a day to instruct University’s personnel in operation, maintenance, and testing procedures of chiller room monitoring system.
B. Train University’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
C. Review data in the operation and maintenance manuals.
D. Schedule training with University, with at least 14 days' advance notice.
E. Provide complete commissioning service by manufacturer’s authorized representative.

END OF SECTION 15635
SECTION 15640 - COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. This section specifies induced-draft, single cell, full stainless steel, counterflow, film-filled, with variable frequency drive compatible totally enclosed air over (TEAO) motor.

1. Industrial duty.
2. Condenser water return inlet (10’’) located at the bottom of the cooling tower with PVC internal piping.
3. Condenser water supply outlet (10’’) located at the bottom of the cooling tower.
4. Equalizer (10’’) connection located at the bottom of the cooling tower, capped for future connection. No flume boxes.
5. Overflow (3’’) and drain (3’’) connection shall be at the side of the cooling tower.
6. Make-up water (2’’) connection shall be at the side of the cooling tower.
7. Tower cleaning (2-1/2’’ supply and 4’’ return) piping fully installed in the factory with side supply and return piping connections.
8. Variable frequency driven motors and fans.
9. Refer to the mechanical drawings for location of all required piping, motor and utility connection locations.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, pressure drop, fan performance, rating curves with selected points indicated, startup instructions, furnished specialties, and accessories for each model indicated.

B. Submittal Drawings: Detailed equipment assemblies and indicate dimensions, weights, loads, required clearances, location of piping connections per mechanical drawings, and method of field assembly, components such as electronic float valve, vibration switch, oil level switch, etc., and location and size of each field connection. Provide all design data required to determine that the cooling tower satisfies all the requirements of this specification section and the mechanical drawings.

1. Design Calculations: Calculated values for selecting seismic restraints consisting of static weight loading, mounting hole dimensions and location of center of gravity.
2. Base Supports Details: Detail fabrication, including anchorage and attachments to structure and to supported equipment.
3. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Show structural supports, piping roughing-in requirements, wiring roughing-in requirements (determine spaces reserved for electrical equipment), and access requirements for service and maintenance.

D. Submittal shall include all motor submittals required under Section 15170.
E. Cooling Tower Sound Data: Cooling Tower sound pressure levels (SPL) in dB and “dB(A)” ratings at 5 and 50 feet from the cooling tower shall not exceed as indicated in the table below. Measure sound pressure levels at air inlets, top and ends of cooling tower. Submit Sound Data as part of basic submittal package. Provide a written warranty from the manufacturer that the cooling tower meets the specified sound levels. The tower manufacturer shall provide remedies should the tower fail to comply. Submit cooling tower sound data for approval. Cooling tower shall meet the following sound requirements:

<table>
<thead>
<tr>
<th>Location</th>
<th>Sound Data (Sound Pressure Levels (SPL) (dB(A)))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor End Side End Motor Side Top</td>
<td></td>
</tr>
<tr>
<td>5 Feet From Tower</td>
<td>84</td>
</tr>
<tr>
<td>50 Feet From Tower</td>
<td>71</td>
</tr>
</tbody>
</table>

F. Maintenance Data: For each cooling tower, provide maintenance manuals for fans, bearings, fan drives, controls, and accessories.

G. Organize operation and maintenance data into suitable sets of manageable size. Bind properly indexed data in individual, heavy-duty, 2-inch, vinyl-covered binders, with pocket folders for folded sheet information. Mark appropriate identification on front and spine of each binder. Include the following types of information.

1. Emergency instructions.
2. Copies of warranties
3. Wiring diagrams.
4. Recommended “turn-around” cycles.
5. Inspection procedures and spare parts list.

H. Include installation instructions, assembly views, and lubrication instructions.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Certification: Certify cooling tower’s thermal performance according to CTI 201.

B. References:

1. ASTM A653/A653M: Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot-Dip Process.
5. NEMA MG 1: Motors and Generators.
7. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.
8. UL 486B: Wire Connectors and Soldering Lugs for Use with Aluminum Conductors.
9. Manufacturer shall be ISO 9002 Certified.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver cooling towers as a factory assembled unit with protective crating and cover.

B. Rig unit for unloading and moving as recommended by the manufacturer.

C. Examine proposed route of moving cooling towers in place and verify that it is free of interferences.
ART CENTER AND SATELLITE COOLING PLANT
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD
BAKERSFIELD, CA

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer shall be Evapco Model USS 224-718, Baltimore Air Coil, or equal.

2.2 INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. General:

1. Provide an induced-draft, single cell, full stainless steel, counterflow, film-filled, TEAO motor, which is mounted out of the air stream and is fully compatible with variable frequency drive. The cooling tower motor shall fully comply with specification Section 15170 Electric Motors. The mechanical contractor shall provide the VFD, which shall fully comply with specification Section 15171 Variable Speed Drives. The cooling tower shall be industrial duty and is factory fabricated and assembled.

2. The tower and all its components shall be designed to withstand a wind load of 30 pounds per square foot, as well as a Zone 4 seismic load per the latest edition of the California Building Code (CBC) requirements. CBC Zone 4 calculations shall be based upon the tower under operating conditions, with hot water basins, cold-water basins, and distribution systems full to their operational levels with water. Calculations shall include the entire tower and shall be submitted for review. Towers with CBC Zone 4 calculations based upon anchorage only, not including the entire tower shall not be acceptable. A registered California Structural Engineer shall stamp all submittals.

3. The cooling tower shall be designed to withstand shipping and hoisting loads of 2g horizontal and 3g vertical.

4. The fan deck and hot water basin covers shall be designed for 50 psf live load or a 200 pounds concentrated load.

5. Handrails shall be capable of withstanding a 200 pounds concentrated live load in any direction, and shall be designed in accordance with OSHA guidelines.

B. Unit Dimension and Weights:

1. The approximate dimensions of the cooling tower shall be 12’-0” wide, 18’-0” long, and 20’-0 high from bottom of the tower to the fan guard.

2. Total operating power of the variable speed driven fan shall not exceed 40 horsepower per cell.

3. Electrical requirements shall be 460 volts, 3 phase, and 60 hertz.

4. The shipping weight shall not exceed 12,000 pounds per cell.

5. The operating weight shall not exceed 21,100 pounds per cell.

C. Except where otherwise specified, all components of the cooling tower shall be fabricated of heavy gauge, Type 304, stainless steel. Coatings or fiberglass may not be substituted. The tower shall be capable of withstanding water having a chloride content (NaCl) up to 750 ppm; a sulfate content (SO4) up to 1200 ppm; a calcium content (CaCO3) up to 800 ppm; silica (SiO2) up to 150 ppm; and design hot water temperatures up to 125°F (51.7°C). The circulating water shall contain no oil, grease, fatty acids, or organic solvents. The specifications, as written, are intended to indicate those materials that will be capable of withstanding the above water quality in continuing service, as well as the loads described above. They are to be regarded as minimum requirements. Where component materials peculiar to individual tower designs are not specified, the manufacturer shall take the above water quality and load carrying capabilities into account in the selection of their materials of manufacture.

D. Performance:

1. The cooling towers shall be guaranteed by the manufacturer to cool 1,670 GPM water flow per cell from 90°F to 80°F at 75.0°F wet bulb temperature.
2. Cooling Tower Institute (CTI) shall certify the thermal rating. CTI Certification notwithstanding, the cooling tower manufacturer shall guarantee that the tower supplied will meet the specified performance conditions as installed, taking into account jobsite conditions that can affect performance such as airflow restrictions due to enclosures, recirculation effects due to adjacent structures, or adjacent heat sources.

E. Fan:

1. Fans shall be heavy duty axial propeller type constructed of aluminum alloy and statically balanced. The fan is installed in a closely fitted cowl with venturi air inlet. Each fan blade shall be individually adjustable. Fan screens are stainless steel and have stainless steel frames bolted to the fan cowl.
2. Fan shaft shall be solid shaft of ground and polished steel. Exposed surface coated with rust preventative.
3. Fan shaft bearings shall be heavy-duty, self-aligning ball type bearings with extended lubrication lines to grease fittings located on access door frame. Bearings are designed for a minimum L-10 life of 75,000 hours.
4. Fan motor shall be totally enclosed air over (T.E.A.O.) ball bearing type electric motor(s) suitable for moist air service. Motors shall have 1.15 service factor design.
5. Fan access shall be through hinge mounted door in the upper casing for fan drive and water distribution system access. Removable louver panels on all four sides of the unit for pan and sump access.
6. Fan drive shall be multi-groove, solid back, reinforced neoprene V-belt type with taper lock sheaves designed for 150% of the motor nameplate horsepower. The belt material shall be neoprene reinforced with polyester cord and specifically designed for cooling tower service. Belt adjustment shall be accomplished from the exterior of the unit. Bearing lube lines shall be extended to the exterior of the unit for easy maintenance. All fan and motor sheaves located in the airstream shall be constructed of aluminum alloy; vented guards shall not be acceptable. If belt adjustment cannot be accomplished from outside of the unit, a gear drive for external motor mount shall be provided.
7. Vibration Cutout Switch: De-energize fan motors if excessive vibration occurs, U.L. Listed. Refer to section R of this specification for additional requirements.

F. Non-Corrosive Hot Water Distribution System: Evenly distributes water over fill material.

1. Each cell of the cooling tower shall have one (1) hot water return inlet connected to a main spray header. The spray header and branches shall be constructed of Schedule 40 polyvinyl chloride (PVC) pipe for corrosion resistance and shall have a stainless steel connection, which is beveled for weld/grooved for a mechanical coupling to attach the external piping. The spray header and branches shall be removable for cleaning purposes and have threaded end caps to allow debris to be removed.
2. Water shall be distributed over the fill by precision molded ABS spray nozzles with large 3/8 by 1 inch orifice. openings and integral sludge ring to eliminate clogging. The nozzles shall be threaded into the water distribution piping to assure positive positioning. All internal piping shall be installed at the factory for single point connection at the bottom of the cooling tower.
3. Each cell of the tower shall include a single hot water inlet connection at the bottom of the cooling tower as shown on the mechanical drawings. An internal system of piping shall deliver water equally to the distribution basins without the need for balancing valves. This internal piping system shall require no scheduled maintenance, and shall be located such that it does not interfere with normal maintenance access.
4. There shall be one single, 10” bottom inlet connection per cooling tower cell to accommodate the return water piping as indicated on the mechanical drawings.

G. Casing: Stainless steel; complying with ASTM A-653 and A-653M. The casing panels shall totally encase the sides of the fill section to protect the surface from direct atmospheric contact.
1. Fasteners: Corrosion resistance equal to or better than the materials being fastened.
3. Welded Connections: Continuous and watertight.
4. Rigging Supports: For handling cooling towers at construction site.

H. Cold Water Basin:

1. The cold water basin and all cold water basin components including vertical supports and air inlet louver frames shall be constructed of heavy gauge Type 316 Stainless Steel. The basin shall include a single, 10" bottom outlet sump with side connection per cell to accommodate the outflow piping system as shown on the mechanical drawings.
2. The entire pan area shall incorporate a stepped configuration for reduced water volume, lower operating weight, and easier pan maintenance. The upper and lower pan bottoms shall be sloped to provide positive drainage of the complete basin.
3. Standard accessories shall include large area lift-out, stainless steel strainers with perforated openings sized smaller than water distribution nozzle orifices; an integral anti-vortex hood to prevent air entrainment; bottom, single overflow, and drain connections per cell as shown on the mechanical drawings.
4. There shall be one, 10” equalizer line connection per cell.
5. There shall be one, 2” make-up water connection per cell at the side of the cooling tower as shown on the mechanical drawings. Suction connections shall be equipped with stainless steel debris screens.
6. There shall be one; overflow (3”) and one drain (3”) connection shall be at the side of the cooling tower.
7. There shall be one make-up water (2”) connection shall be at the side of the cooling tower.
8. All steel items, which project into the basin (columns, diagonals, anchor clips, etc.), shall also be made of stainless steel.

I. Tower Cleaning System Piping:

1. The cooling tower manufacturer shall furnish tower cleaning system piping within the cold water basin.
2. Provide 2-1/2” diameter sweeper pipe with four 3/4” distribution holes at each air inlet evenly spaced for snap on swivel heads. Jets screw into swivel heads.
3. Provide 4”, water tight, stainless steel fittings, through the side of the cooling tower, which shall be connected to the 2-1/2” supply and 4” return pipes from the tower cleaning system filter.
4. Provide proposed tower cleaning system sweeper piping layout for approval by Engineer.

J. Fill Material:

1. Polyvinyl Chloride (PVC) of cross-fluted design.
2. PVC sheets are bonded together for strength and durability.
3. Fill is self-extinguishing for fire resistance, has a flame spread of 5 under A.S.T.M. designation E-84-81a, and is resistant to rot, decay and biological attack.

K. Drift-Eliminator:

1. Material shall be PVC and triple-pass.
2. The eliminator design shall incorporate three changes in air direction to assure removal of all entrained moisture from the discharge air stream.
3. Maximum drift rate shall be less than 0.001% of the circulating water rate.

L. Air Inlet Louver Screens:
1. The louver screens shall be constructed of polyvinyl chloride (PVC) and mounted in easily removable Type 316 SS frames on all four sides of the cooling tower for access to the entire basin area for maintenance.

2. The louvers shall have a minimum of two changes in air direction to prevent splash out, block direct sunlight from entering the basin, and have a 3/4” opening to prevent debris from entering the basin.

M. Water-Level Control:

1. Cooling tower manufacturer shall provide hydraulically operated, diaphragm actuated, globe pattern make-up water valve for each cell.

2. The make-up water valve shall be manufactured by CLA-VAL or equal (no known equal).

3. CLA-VAL size shall be 2” threaded connection for 20 GPM water flow rate per cell.

4. The CLA-VAL valve shall be shipped loose from the factory and field installed by contractor.

N. Motors

1. Refer to Section 15170 “Electric Motors” for general requirements for factory-installed motors.

2. Refer to Section 15171 “Variable Frequency Drives” for general requirements.

3. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B, suitable for use with variable frequency drive. Refer to Section 15170 for further details.

4. Enclosure Type: Cooling Tower CT-1 & 2 shall utilize 50 horsepower motors mounted outside the air stream.

5. The enclosure shall be totally enclosed air over (TEAO).

6. Motors shall be of the premium energy efficient type, 1.15 service factor, variable torque, designed specifically insulated for cooling tower service.

7. Motor shall be furnished with special moisture protection windings, shafts and bearings.

8. Fan motor shall be inverter duty type designed per NEMA standard MG1, Section IV, Part 31.

9. Speed and electrical characteristics shall be 1800 RPM single winding, 3 phase, 60 hertz, 480 volts.

10. Motor shall operate in the shaft-horizontal position, and nameplate horsepower shall not be exceeded at design operation.

O. Access

1. Handrails shall be designed to withstand 200 lbs. of concentrated live load in any direction, and shall be in accordance with OSHA guidelines.

2. Provide aluminum exterior ladder to top of cooling tower, securely mounted to the cooling tower. A heavy gauge galvanized steel safety cage shall surround the ladder. The ladder shall extend to grade. The bottom of cooling tower will be approximately 5’-0” above finished grade.

3. Provide perimeter handrails at top of cooling tower if required for top of tower maintenance.

P. Warranty:

1. The entire cooling tower, including structure, casing, basins, decking, fans and motors, and all mechanical drive components shall be warranted against failure due to defects in materials and workmanship for five (5) years from date of shipment to the job.

Q. Accessories:

1. Cooling tower manufacturer shall provide a vibration alarm switch per cell, which shall be mounted near the motor. The vibration limit switch shall be installed on the mechanical equipment support assembly and wired into the control panel. The purpose of this switch will be to interrupt power to the motor in the event of excessive vibration. It shall be adjustable for sensitivity, and shall require manual reset. Vibration switch shall be U.L. Listed. Vibration
switch manufacturer shall be Metix Vibralert Mechanical Switch Model 5550 or engineer approved equal.

2. Cooling tower manufacturer shall provide Type 304 stainless steel, mesh screen at fan discharge section and air intake louver section to prevent debris from entering the cooling tower. Submit mesh screen details for approval.

3. Oil level switch – not required for belt driven units.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to support cooling tower.

B. Verify piping and wiring roughing-in locations.

C. Verify suitability of branch-circuit wiring.

3.2 INSTALLATION

A. Install cooling towers according to manufacturer’s written instructions.

B. Install cooling towers level and plumb, and fasten to supporting structure with seismic restraints.

C. Maintain recommended clearances for service and maintenance.

D. Install cooling towers and their support structures to withstand the effects of seismic events according to authorities having jurisdiction. Cooling tower will be mounted with 1/2 inch thick neoprene vibration pad provided by the cooling tower manufacturer. Each pad will span full width of the support beam and minimum 1'-0" long. Use dielectric bolt set to anchor the cooling tower to the supporting structural beam.

E. Electrical Wiring: Install electrical devices furnished by cooling tower manufacturer that are not factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to cooling towers to allow service and maintenance.

2. Pitch piping down to drain into sump.

3. Connect overflow drain and bleed lines to sanitary sewage system.

4. Domestic Water Piping: Comply with applicable requirements of Division 15.

5. Connect to water-level control with shutoff valve and union or flange at each connection.

6. Hot-Water Piping: Comply with applicable requirements of Division 15 Section valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection.

7. Condenser-Water Piping: Comply with applicable requirements of Division 15. Connect to supply and return cooling-tower connections with shutoff valve, flow control valve, and union or flange on supply connection to the tower and shutoff valve and union or flange to return connection from the tower to the chiller.

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.

3.4 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. Report results in writing.

3.5 ADJUSTING

A. Set and balance condenser-water flow at tower inlet.

B. Adjust water-level control for proper operating level.

3.6 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

3.7 COMMISSIONING

A. Complete installation and startup checks according to manufacturer’s written instructions and do the following:
   1. Clean entire unit and wash basins.
   2. Ensure accessories are properly installed.
   3. Check makeup water float.
   4. Check clearances for airflow and for tower servicing.
   5. Check for vibration isolation and structural support

B. Ensure fan wheels rotate in correct direction without vibration or binding.

C. Start cooling-tower and condenser-water pumps. Follow manufacturers written starting procedures.

D. Check water level in tower basin.

E. Ensure system chemical treatment is working, and measure chemical treatment levels. Check operation of tower basin automatic blow-down, and controlling device.

F. Verify that tower discharge is not re-circulating into air intakes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel as specified below:
   1. Train Owner’s maintenance personnel on procedures and schedules for stating up and shutting down, troubleshooting, servicing, and maintaining cooling towers.
   2. Review data in maintenance manuals. Refer to Division 1 Section “Project Closeout.”

END OF SECTION 15640
PART 1 - GENERAL

1.1 SCOPE

A. This section specifies a turnkey supply of a vertical, cylindrical, flat bottom type, all welded steel tank for the storage of chilled water for use in the facility building cooling systems.

B. Construction includes designing and providing a welded steel tank and appurtenances and foundation for the storage of chilled water. The work to be performed under these specifications includes furnishing all labor, materials, tools and equipment necessary to design, fabricate, construct, inspect and test a welded steel thermal energy storage (TES) tank, including the foundation, insulation and accessories as shown on the drawings and specified herein.

C. The storage system shall employ the principle of thermal stratification for storing warm and cold water in a single storage container.

D. The supplier shall provide a thermal energy storage (TES) system complete with all internal flow distributors necessary for storage of thermally stratified chilled water. The supplier shall also provide a guarantee of the thermal performance of the cool storage system.

E. The TES system will be integrated by the TES System Contractor with the chilled water system. The TES system will store chilled water produced during "off-peak" periods to meet "on-peak" thermal loads.

1.2 QUALITY ASSURANCE

A. Standards: The tank and foundation design, fabrication and installation shall conform to the following standards:

1. Materials And Construction: AWWA D100
2. Welding Procedures: ASME Section IX
3. Steel Plates: AWWA D100
4. Structural Shapes: ASTM A36
5. Foundation Concrete: ACI 301 & 318
6. Cathodic Protection: NACE RP-038-88
7. Painting: AWWA D102 and SSPC
8. Electrical: NFPA 70
9. Piping: ASME/ANSI B31.1

B. Design Requirements:

1. The tank shall be capable of storing a minimum of 7,200 ton-hours of thermal energy in the form of chilled water.
2. During recharge the flow rate shall be 1,800 GPM, the warm water at 59°F will be removed from the storage system. Cold water at 39.2°F will be returned to the tank at an equal flow rate.
3. During discharge the flow rate shall be 1,800 GPM, the cold water at 40°F will be removed from the storage system. Warm water at 59°F will be returned to the tank at an equal flow rate.
4. The chilled water tank assembly shall limit ambient heat gain to less than 2% of the rated thermal storage capacity in a 24-hour period based on a 100°F ambient temperature.
5. Tank dimensions shall be 43 feet diameter maximum, with a maximum height of 57 feet a maximum water level of 54 feet high.
6. Total hydraulic head loss from the tank inlet flange to the tank outlet flange at the future maximum design flowrate of 2,500 gpm shall be a maximum 3.0 psi.
7. The drawings of the steel tank are intended to define general dimensional requirements and tank configuration. Inlet, outlet, overflow, ladder, make-up, vent and drain configuration shall be generally as shown.
8. The TES System Contractor shall design the tank, tank anchorage and foundation and all required structural supports and stiffeners in accordance with the requirements contained herein.
9. The tank design shall be stamped and signed by a California registered professional structural engineer.
10. The overflow pipe and inlet pipe supports shall be designed in accordance with AWWA D100 standards.

C. Field Tests: Welded joints tested by radiographic method per AWWA D100.

D. Warranties:
1. The TES System Contractor shall provide a one-year warranty for thermal energy storage system materials and workmanship to commence upon Completion of the project.
2. The TES System Contractor shall also provide a guarantee of the thermal energy storage system performance as specified in paragraph 1.02-B.

E. Pre-Qualification of Contractor
1. The Contractor must have a minimum of ten years experience in the turnkey design and supply of operating TES Tank Systems. The system and internals provided shall be of the Contractor’s own design and shall utilize principles and details proven operationally successful by field installations.
2. Upon request the Contractor shall provide a minimum of five references (with customer contacts) for similar, thermally-stratified, chilled water storage installations currently in operation, each utilizing modular internals of the Contractor’s own design that meet the requirements of this specification.
3. Upon request the Contractor shall provide a minimum of three successful performance test results for chilled water storage installations currently in operation, each utilizing modular internals that meet the requirements of this specification.
4. Upon request the Contractor shall provide a minimum of two Factory Mutual certificates for dual service fire water protection and chilled water storage installations currently in operation.

1.3 SUBMITTALS

A. The following information certified by a Professional Structural or Civil Engineer licensed in the State of California and submitted by the Contractor in compliance with Specification Section 15010:
1. Submit shop drawings and structural calculations for tank, tank anchorage and foundation shall be stamped and sealed by a California registered professional structural engineer.
2. Tank orientation and elevation views.
3. Tank penetrations and points of interface with other contractors.
4. Tank sizing calculations, internal flow distributor sizing calculations, pressure drop calculations and heat gain calculations.
5. Insulation jacket color samples shall also be submitted to The College for selection of exterior color.
6. Provide detailed location for all tank connections.
7. The Engineer shall review and approve the insulation jacket.
1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of paragraph 15010-1.14.

B. The TES system supplier shall provide 6 copies of an Operation and Maintenance Manual. The TES supplier shall submit the operation and maintenance manual to the Construction Manager with submittal to confirm proven/acceptable system operation and maintenance procedures. As a minimum, the manual shall include the following:

1. Thermodynamic description of each operating mode,
2. Safety precautions and instructions,
3. Detailed performance test procedure,
4. Recommended spare parts list,
5. Recommended maintenance practices and schedules for the tank foundation, structure, and appurtenances, and for the corrosion protection, insulation and internal distribution systems,
6. Local and factory contacts for the storage supplier, and for the O.E.M. suppliers of major components, as appropriate.

C. The manual shall be delivered prior to commissioning.

1.5 UNIT RESPONSIBILITY

A. The TES System Contractor shall cause the equipment specified under this section to be furnished by a single supplier who shall be fully responsible for the design, selection and operation of all systems and components furnished therewith.

B. Nothing in these provisions, however, shall be construed as relieving the TES System Contractor of responsibility for the overall quality and completeness of the work.

1.6 GEOTECHNICAL INVESTIGATION

A. The College shall provide an up-to-date soils investigation report furnished by a qualified Geotechnical Engineer.

B. The selected soils engineer for this project is:

BSK & Associates
117 “V” Street
Bakersfield, CA 93304
Phone: 661-327-0671

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Tank manufacturer shall be:

1. Chicago Bridge and Iron Company
2. Paso Robles Tank
3. Or equal
2.2 FOUNDATION

A. A complete foundation for the tank shall be designed and installed by the TES System Contractor meeting the requirements of AWWA D100 and ACI 318.

B. The supplier will design and install the foundation to meet the following:
   1. Tank foundation shall be sufficient for the tank based on the soils report provided by the selected campus soils engineer.
   2. The foundation shall be sloped to prevent accumulation of rainwater and shall include a sand/cement grout mixture as specified in AWWA D100 and a clean sand pad under the tank bottom.

2.3 TANK

A. Tank:
   1. The storage tank will be an above-ground, vertical, cylindrical, flat bottom, column-supported, fixed roof tank of all-welded steel construction and will be designed, constructed, and tested per the latest edition of AWWA D100.
   2. AWWA D100, Appendix C may be employed at the manufacturer's discretion.
   3. The tank and tank anchorage, will be designed and supplied for CBC Zone 4 seismic design requirements and for 100 mph wind conditions.
   4. As specified by the Engineer, the tank shall have freeboard adequate to accommodate one half the amplitude of the "sloshing wave" generated as a result of a seismic event.
   5. The tank roof will be designed for a live load of 25 PSF.
   6. The bottom and roof plates will be joined by lap joints, welded continuously from the top side only.

B. Tank Center Column and Roof Rafters: All roof rafters, support columns, and flow conductors shall be of all welded design. No permanent bolted/flanged connections are acceptable.

C. Overflow Detail: The top of the internal tank overflow shall be a conical weir. Box type overflows are unacceptable.

D. Lightning Protection: Lightning protection shall be provided in accordance with NFPA 780.

E. The bottom and roof plates shall be assembled using lap joints, welded continuously from the top side only. Shell plates to be 100% full fusion butt-welded joints.

F. Seismic Coefficients per AWWA D100, Table 24-27:
   1. Zone Coefficient (Z) = 0.4
   2. Use Factor (I) = 1.0
   3. Site Amplification Factor (S) provided by the Geotechnical Engineer

2.4 TANK FITTINGS AND ACCESSORIES

A. General: The tank shall have as a minimum the following fittings and accessories:
   1. One 30 inch diameter shell access manhole with hinged door.
   2. One 24 inch diameter shell access manhole with hinged door.
3. Two 24 inch diameter roof manholes (one located near the center of the roof).
4. One 12 inch diameter COLD water inlet/outlet nozzle for chilled water supply (CHWS).
5. One 12 inch diameter WARM water inlet/outlet nozzle for chilled water return (CHWR).
6. One 6 inch diameter overflow nozzle with an internal overflow pipe and an external seize-restraint, anti-thermosiphon device.
7. One 6 inch diameter drain nozzle with a block valve of a freeze-resistant design and internal drawoff piping.
8. One 24 inch diameter roof vent (screened per AWWA D100, if required).
9. Minimum fifteen (15) 1"ø x 2' long, carbon steel, shell-mounted thermwells.
10. One straight external ladder with galvanized safety device with two (2) harnesses and a walkthrough at the roof with 10' of handrail.
11. Four grounding lugs.
12. One 4 inch diameter fire hose connection.

B. High Water Level Alarm: The tank shall include a high water level switch and a high water level alarm, which shall be connected to the energy management system.

2.5 INTERNAL FLOW DISTRIBUTORS

A. The tank supplier shall provide all necessary internal flow distributors required to meet the thermal performance specifications as indicated in paragraph 15780-1.2-B. These internals shall be fully designed, fabricated, and installed by the tank supplier. The design shall be based upon proven flow distribution calculations to maintain the operating thermocline between the cold and warm water.

B. The distributors shall make maximum practical use of corrosion resistant, modular components sized to pass through the shell and roof manholes for easy removal and installation. The individual modular diffuser components shall be capable of simple disassembly and reassembly to facilitate inspection and painting of the tank bottom and the roof support column(s). Such disassembly and reassembly shall be accomplishable without any cutting, burning, welding, or gluing.

C. The diffuser shall be capable of being expanded to meet possible future flow rates of up to 125% of the currently specified maximum from paragraph 15780-1.2-B.

2.6 TANK INSULATION

A. Insulation shall be provided as required to meet the thermal performance specifications of paragraph 15780-1.2-B. The shell and roof insulation shall be an external panel system consisting of two layers of urethane foam each with pre-attached foil vapor barrier faces. The aged thermal conductivity value for the urethane thickness determination shall be less than 0.16 btu-in/hr-ft2-°F. Each of the vapor barrier foil seams shall be sealed with vapor tight tape. The panels shall be secured to the tank side and roof; and a weather-protective and mechanically protective aluminum jacket of 0.024" minimum thickness, with vertical standing closure seams, shall be attached (corrogated aluminum is not acceptable). The seams between aluminum jacket panels, and the seams at the top and bottom of the tank shall insulation, shall be sealed vapor tight. The insulation and jacketing attachment system shall be designed to withstand a 100 mph wind, and shall be concealed behind the aluminum jacket. External banding or screw attachment of the aluminum shall not be considered an adequate attachment. The exposed insulation jacket shall have a textured finish and its color shall be as selected by the Engineer.

B. External bottom insulation shall be provided as necessary to meet the heat gain limit of paragraph 15780-1.2-B and shall be suitably protected from damage during installation and welding of the tank bottom.
2.7 TANK COATING

A. The coating system shall be as follows:

1. Outside, under bottom: None
2. Outside, if uninsulated: AWWA D102 system I-I-S
3. Outside, to be insulated: One primer coat (5 mil DFT) from the AWWA D102 system I-I-W
4. Inside: AWWA D102 system I-I-W

B. Prior to shop priming of any coated tank surfaces, mill scale and rust will be removed by blast cleaning per SSPC-SP 10.

C. Following tank erection and welding, and prior to field priming, patch priming or finish coating of any tank surfaces, damaged or uncoated areas will be blast cleaned per SSPC-SP 10.

D. Coatings will only be applied during temperature, humidity, and cleanliness within the limits recommended by the coating manufacturer.

E. Galvanized surfaces require no additional coatings. Erection damage, if any, is to be touched up with "Galvanox", or equal.

F. The exposed external tank paint color shall be selected by the Engineer.

2.8 CATHODIC PROTECTION

A. The cathodic protection system shall be designed by a corrosion specialist who is either a Registered Professional Engineer or certified by the National Association of Corrosion Engineers (N.A.C.E) with a minimum of five years experience with cathodic protection systems design of waterworks related systems.

B. The TES System Contractor shall submit design calculations and drawings of the system, components and system layout by the corrosion specialist. This design along with catalog sheets of all primary cathodic protection materials and test station shall be submitted to the Engineer for approval.

C. Steel Tank Bottom

1. The TES System Contractor shall provide engineering services, materials, equipment, labor and supervision to furnish an impressed current cathodic protection between the steel tank bottom and the surrounding soils.
2. Provide a cathodic protection anode grid system, constructed of coated titanium ribbon installed under the bottom of the storage tank.
3. Furnish all testing services, labor, equipment and materials to install the protecting anodes, reference cells, junction boxes and rectifier for protection of the external surface of the tank bottom. The system includes permanent reference cells, DC positive and negative wiring from the rectifier to the tank.
4. Protection system components include the following:
   a. Coated Titanium Anode Ribbons
      1) The anode ribbon shall be a titanium substrate with a TIR 2000 metal oxide coating as supplied by Materials Protection Company, Houston, Texas or approved equal. The titanium substrate shall be as follows:
b. Titanium Conductor Bars
   1) Titanium conductor bars shall be used to form a grid pattern and thereby reduce the voltage drop along the ribbon anode. The conductor bars shall be:
      a) Composition: ASTM 265: Titanium, Grade 1
      b) Width: 0.25 inches
      c) Thickness: 0.025 inches
      d) Weight: 6 pounds per 500 feet
      e) Resistance: 0.042 ohms per foot

c. Power Feeds from local 120 VAC source
   1) Power feeds shall be shop fabricated and shall consist of:
      a) A No. 8 AWG, stranded copper insulated with high molecular weight polyethylene. The polyethylene shall confirm to ASTM D1248, Type I, Class C, Grade 5. The cable shall be of sufficient length to extend without splicing, from point of connection on the anode to splice box mounted foundation exterior.
      b) The conductor shall be exposed at the end of the cable and connected to a 1/8 inch diameter by 4 inch Ion Titanium rod with a Burndy, hydraulically compressed, splicing sleeve.
      c) A Kynar heat shrink sleeve shall be placed in the center of the titanium rod. Mastic sealant shall be half-lapped over the compression sleeve and the entire splice shall then be sealed with epoxy splice it, 3M Type 82F1 or approved equal.

d. Permanent reference cells shall be zinc and copper, copper-sulfate reference electrodes.
   1) Zinc reference cells shall be 1.4 inches by 1.4 inches by 9 inch electrodes, pre-packaged in quick wetting backfill. The zinc alloy shall confirm to ASTM B41880, Type II.
   2) Copper, Copper-sulfate reference cells shall be constructed of a 2-inch diameter by 8 inch long Schedule 80 PVC pipe with an ion trap on one end to prevent contamination. The electrode shall have a design life of 15 years and a stability of plus or minus 5 millivolts under a 3.0 microamp load.
   3) Permanent reference electrodes shall be equipped with No. 14 AWG, stranded copper conductors with high molecular weight polyethylene insulation. Lead wires shall be of sufficient length to extend to the anode splice box without splicing.

e. Junction Box and Related Wiring
   1) All wiring from the anode splice box shall terminate in a metallic junction box equipped with phenolic panel, hinged cover and the following:
      a) Insulated, numbered terminal blocks for the reference cells leads.
b) A 1/4 inch thick by 1 inch wide copper and with two 0.001 ohm Type SS shunts for termination of the power feeds. Each shunt shall be identified by a letter. An SLU 70 cable lug shall be connected to the copper bar for the DC positive cable to the rectifier.

f. Rectifier and Related Wiring

1) Rectifier shall be the product of a concern currently engaged in the manufacturer of cathodic protection equipment and shall perform in all aspects to NEMA Standards. The rectifier shall be dual circuit, silicon fullwave bridge, 120 VAC, 60 Hz, single phase, air cooled designed for continuous operation at 45 degree C ambient temperature and shall include the following features:

   a) Output rating shall be sized by the corrosion engineer.
   b) Transformer taps shall permit manual adjustment of output voltage between zero and maximum voltage in 20 evenly divided steps.
   c) Thermal magnetic circuit breaker, plastic encased, for overload protection of primary and secondary.
   d) Transient protection for AC and DC circuit.
   e) Lighting protection for primary circuit.
   f) Separate meters for current and voltage output with 2 % accuracy.
   g) Silver plated connectors and adjustment bars.
   h) Pressure type connectors for DC output cables marked “Tank Bottom” and “Anode”.
   i) Filters to minimize the AC component in the DC outputs and to reduce interference with radio, telephone and communication circuits.
   j) Efficiency Filter: The DC output filter shall be fitted with a bypass circuit and switch of sufficient capacity for 150% of the full load. the switch shall be marked “Efficiency Filter” with “OFF” and “ON” positions clearly labeled. With the Efficiency Filter switch in the “on” position, the bypass circuit shall be open, and the DC output filter shall be in operation.

 g. Air Cooled Rectifier Enclosure

1) Housing shall be a pedestal mounted enclosure, weatherproof, ventilated type, constructed of 11 gauge minimum sheet steel, free of scarp and wrinkles, and shall be equipped with a padlock clasp.

2) The ventilation opening shall be covered with a 16 gauge or heavier cold rolled expanded steel screen. The screen shall be shielded by an appropriate metal barrier that shall positively prevent wires and other metallic objects inserted through the screen from contacting energized components within the rectifier. Cooling to the rectifier shall not be adversely affected by the steel barrier. All surfaces shall be painted with one coat of high quality primer and two coats of gray enamel.

3) Operation and Maintenance Manual shall be provided including a complete wiring diagram and parts lists identifying all features.

5. Anode Grid Installation:

   a. Roll the anode ribbon from the spools and hold in place with sandbags as required to keep from rising above the compacted sand.
   b. Uncoil the conductor bar over the anode ribbon. Using 1.5 KVA Miller Welder, Model 1515, resistance weld each intersection of the anode ribbon and conductor bar. Check each weld to ensure that it is secure.
c. Connect the prefabricated power feeds to the conductor bar and route the No. 8 AWG cables to the conduit penetration of the foundation wall.

6. Permanent Reference Cell Installation:
   a. Soak the cloth sack containing the defence cells in a container of water for 15-20 minutes.
   b. Dig a hole in the sand for placement of the reference cell.
   c. Backfill the cell with additional sand to prevent drying.
   d. Route the No. 14 AWG lead wires to one of the two 3 inch conduit penetrations of the foundations wall.

7. Junction Box Installation:
   a. Mount the junction box on the side of the rectifier cabinet.
   b. Terminate the reference cell lead wires on the numbered, insulated terminal block. Record the identification number for each cell on the As Built Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install tank on foundation in accordance with the manufacturer’s tank design requirements.
   B. Mechanical contractor shall provide the 12 inch diameter chilled water supply (CHWS) and chilled water return (CHWR) OS&Y Gate Valve at connection.
   C. Mechanical contractor shall provide the 6 inch diameter overflow OS&Y Gate Valve at connection.
   D. Mechanical contractor shall provide the 6 inch diameter drain OS&Y Gate Valve at connection.

3.2 NON DESTRUCTIVE EXAMINATION
   A. All radiography shall be performed concurrently with the construction of the tank by the tank fabricator's own work force and not subcontracted. The radiographic examination shall be qualified in accordance with the guidelines of SNT-TC-1A (August 1984 Edition). Level II or III personnel shall be used to perform and evaluate. Film processing shall meet the requirements of paragraph T-231.2 m(ASME Section V, Article 2) and paragraph 22.2 (ASME Section V, Article 22).

3.3 FILLING
   A. The tank shall be cleaned and painted inside and out before filling in accordance with the tank manufacturer’s requirements. The tank shall then be filled with clean water in 1/4 increments at every 2 or 3 day intervals.

3.4 HYDROTESTING
   A. After the tank has been filled, all outlets shall be blocked and a hydrotest shall be conducted to identify any pinhole leaks. As called out in Section 11 of AWWA D100, this hydrotest shall be done after the tank has been painted. The TES System Contractor and the tank manufacturer shall agree to this
procedure. If leaks are identified, the TES System Contractor shall remove water from the tank so that the remaining water level is 2 feet below the lowest leak. The TES System Contractor shall then repair all identified leaks and refill the tank at his/her expense. The TES System Contractor will pay for expenses for repairing the painting around the repaired leaks and for the water required to refill the tank. This hydrotest procedure shall be repeated until no leaks are identified.

3.5 WATER TREATMENT

A. The AWWA paint systems specified in section 4.5 are intended to provide corrosion protection for the tank. However, consideration will be given to the use of water treatment for protection of the balance of the HVAC system components against corrosion, biofouling and sludge deposits. Water treatment shall be specified, supplied and installed by others as described in Section 15545. The TES System Contractor shall verify that the proposed water treatment system is compatible with the tank paint system.

B. The tank supplier shall provide the tank in a broom-clean condition. Final flushing/cleaning of the completed system shall be performed by the TES System Contractor in conjunction with their flushing/cleaning of the interconnecting piping, prior to initial water treatment of the system.

3.6 PERFORMANCE TEST

A. Under direction of the Construction Manager, the TES System Contractor shall conduct a performance test of the TES system to verify the ability of the TES system to comply with the design requirements. This test shall take place within 30 days of Completion. The test shall be conducted by the TES System Contractor and witnessed by the Engineer.

B. Prior to the performance test the TES System Contractor shall calibrate all temperature elements mounted every 2 feet vertically up the tank shell, approximately 15 temperature sensors. This shall be done with a calibrated referenced instrument. Flow meter readings shall also be checked and calibrated using pump head measurements, calibrated balance valve readings, energy balance calculations, or other means. This instrumentation shall be used to monitor the temperature of the water in the tank, the flow of water into the tank, and the thermal stratification performance of the TES system.

C. Since it is unlikely that the full building load will be available at the time of testing, the performance test shall be based on recharging the TES system.

D. Prior to the performance test, the TES system shall be brought to a steady state full discharge condition, as determined by the thermal charge instrumentation.

E. The performance test shall be conducted by withdrawing warm water from the top of the tank at up to the maximum design rate. The warm water shall be cooled to the specified cold temperature and returned to the tank bottom.

F. The inlet/outlet flow and temperature shall be recorded at fifteen minute intervals. The refrigeration delivered into storage during these intervals shall be calculated from the flow and temperature recording; the total stored refrigeration shall be the sum of all periods.

G. The TES system will have met the specified performance requirements if after the flow of one complete tank volume, the total stored refrigeration is equal to or greater than the design requirements (within the accuracy of the flow and temperature instrumentation).

END OF SECTION 15780
SECTION 15855 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies outdoor, custom air handling units, roof curb, accessories and hardware.

1.2 QUALITY ASSURANCE:

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

B. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

- ASTM D395 Rubber Property--Compression Set, Test for
- ARI Air Conditioning and Refrigeration Institute.
- AGMA American Gear Manufacturer's Association.
- ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers.
- ASME American Society of Mechanical Engineers.
- ANSI American National Standards Institute, Piping Standards and Codes.
- NEMA National Electrical Manufacturer's Association.
- UL Underwriter's Laboratory.
- AMCA Air Moving and Conditioning Association.
- CEC California Electrical Code.
- JIC Joint Industries Conference.

C. Air handling unit(s) and component equipment shall be designed, constructed, inspected, tested and stamped in accordance with the latest minimum requirements and recommendations of the following societies and associations:

- NAFM National Association of Fan Manufacturers.
- CEC California Electrical Code.

D. The Manufacturer/Contractor (Supplier) shall comply with any requirements covered in the Division 15 Specification Sections that may be in excess of, but not contrary to, the above mentioned codes and standards.
1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit the following as a minimum:

1. All components, dimensional data, selection data and equipment weight.
2. Submit detailed unit shop drawings. Draw to minimum 1/4 inch equals 1 foot scale on drawing sheets same size as the Contract Drawings.
3. Submit fan curves, chilled water cooling coil selections and filter and filter frame data.
4. Submit motor data per Section 15170 and variable frequency drive (VFD) data per Section 15171. Submit data indicating motor with shaft grounding.
5. Submit roof curb data. Provide shop drawings detailing the mounting and securing for air handling unit to roof curb.
6. Reinforcing details and spacing, including wall panel construction, panel joints, wall and roof framing system, base framing system, and floor and drain pan construction, and methods of assembly.
7. Provide sound power level data at equipment outlet, inlet, and casing radiation at rated capacity and specified pressure.
8. Submit electrical requirements; clearly identify each point of connection for power for the equipment.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Deliver products to site. Store under temporary cover and protect from damage. Do not store units directly on grade.

B. Protect units from damage by storing off site until roof-mounting frames are in place, ready for immediate installation of units.

C. Coordinate with the Owner’s Designated Representative for careful unloading, rigging, and handling of the unit.

D. Coordinate with Owner’s Designated Representative for proper protection of roof system when moving equipment across roof.

E. Rig units to comply with manufacturer's rigging and installation instructions for unloading units, and moving them to final location.

1.5 EXTRA MATERIALS:

A. Provide one complete set of additional pre-filters only.

1.6 ORDINANCES AND REGULATIONS:

A. Equipment shall strictly comply with laws, ordinances, regulations, codes and other authority having jurisdiction over its installation and use. Where any requirements of the above authorities may conflict, the highest requirement shall govern.
1.7 OPERATION AND MAINTENANCE DATA

A. Include data on design, inspection and procedures related to preventative maintenance.

B. Provide Operation and Maintenance manuals shall be submitted at the time of unit shipment.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturer shall be Energy Labs, Governair, HuntAir, Temtrol or Haakon.

2.2 GENERAL

A. Unit shall be factory fabricated, consisting of minimum 6 inches high structural base, rigging and hoisting connections, casing and frame, access doors, supply fan, cooling coils, filter units, internal lights, partitions and other apparatus specified or shown.

B. Shop fabricate casings to greatest extent possible with a minimum of joints and to minimize field fabrication and assembly. Disassemble, as necessary, for shipping and handling. Supplier shall ship fully assembled units to the project site wherever possible.

C. Air handling units shall be shipped in large multiple split sections due to shipping requirements and/or site access conditions. All necessary hardware, sealant, instructions, etc. shall be furnished by the unit manufacturer. A factory technician shall be on site to supervise the installation and assembly of the split sections.

2.3 STRUCTURAL BASE

A. Heavy duty structural steel “C” channel or tubular steel base frame that will support all unit components. The base shall be minimum 6 inches high and consist of welded structural members.

B. Base shall be primed with rust inhibiting primer, and finished with rust inhibiting exterior enamel (Rustoleum or equivalent). Base shall include properly located lifting lugs or brackets.

2.4 CASING – INTEGRAL FRAME TYPE UNITS (OPTION 1)

A. Provide factory-fabricated air handling units with capacity as indicated on the mechanical drawings. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service. All units shall come completely assembled. Multiple sectioned units shall be shipped as a single factory assembled piece de-mountable into modular sections in the field by the contractor. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by the contractor. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 211, 300, 301, 500 and ARI 410. All electrical components and assemblies shall comply with NEMA standards. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.” Units shall comply with latest edition of California Electrical Code, as applicable for installation and electrical connections of ancillary electrical components of air handling units. Units shall be UL or ETL listed.
B. Unit Base and Floor: Heavy removable lifting lugs shall be added to the perimeter channel along the longest length of the unit. The unit floor shall be fabricated of 0.125” thick, #3003 aluminum tread plate sheets. The floor shall be supported by structural and minimum 12-gauge formed galvanized steel members. Max spacing of floor support shall be 24” centers. These formed members shall be welded to other members for maximum strength. Floor skin shall be supplied with standing seams design and drive cleats to maintain water and airtight seal. The flooring shall be spot welded to the members below. No penetrations thru the floor skin shall be acceptable. Welds shall be below the floor and spaced no greater than 6” on center.

C. Exterior Panels: The unit housing side and roof panels shall be constructed of 16-gauge galvanized steel, and shall utilize a standing seam modular panel type construction. The panels shall be caulked and attached to each other, to the roof, and to the floor using nuts and bolts. Drive screw attachment is not acceptable. All panels shall be removable. All seams shall be sealed with an acrylic latex sealant prior to assembling the panels and after completion of the assembly. All floor openings shall have 12 gauge galvanized steel-framed flange around the entire perimeter of opening for duct connection. Provide necessary support to limit casing deflection to 1/200 of the narrowest panel dimension. If panels cannot meet this deflection, add additional internal reinforcing. All panel seams shall be caulked and sealed for an airtight unit. Leakage rates shall be less than 1% at design static pressure.

D. Insulation and Interior Liner: Insulation shall be 2” thick, 3 lbs per cubic foot density, neoprene coated fiberglass to cover all walls and ceilings. This insulation shall meet NFPA-90A smoke and flame spread requirements. All floors shall be insulated from below using minimum 1” thick foam to insure that the entire under surface of the floor is insulated. There shall be no raw edges of insulation exposed to the air stream. Plenum fan sections shall have a 20 gauge perforated galvanized sheet metal liner covering all wall and ceiling surfaces in the blast area of fan. The entire interior of all units shall be lined with minimum 20 gauge bright galvanized steel liner. The interior liner of the fan sections, inlet plenum sections, and discharge plenum sections shall be perforated and the remaining shall be steel.

E. After final assembly the unit exterior shall be coated with an industrial gradeself priming semi gloss high solids 2K polyurethane gray 219GY1 finish. In addition, all fan bases, springs, and structural steel supports shall be coated with the same finish. The paint system shall meet ASTM B117 Salt spray test for a minimum of 2000 hours.

2.5 CASING – WELDED FRAME TYPE UNITS (OPTION 2)

A. Provide factory-fabricated air handling units with capacity as indicated on the mechanical drawings. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service. All units shall come completely assembled. Multiple sectioned units shall be shipped as a single factory assembled piece de-mountable into modular sections in the field by the contractor. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by the contractor. Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARI 410. All electrical components and assemblies shall comply with NEMA standards. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.” Units shall comply with NFPA 70, “National Electrical Code,” as applicable for installation and electrical connections of ancillary electrical components of air handling units. Units shall be UL or ETL listed.

B. Unit Base and Floor: Provide a full perimeter welded base frame manufactured with structural steel tubing and C-Channel cross support members on close centers. Entire base frame shall be painted with an industrial DTM finish with built-in rust inhibitors. Base rails shall be fitted with lifting lugs at the corner of the unit or section (if de-mounted). The base shall include a 4-inch thick insulated “double bottom” floor with minimum 20 gauge G-90 galvanized outer and 16 gauge G-90 galvanized inner walk-
on surface. All floor seams shall be caulked and sealed for an airtight unit. Single wall floors with glued and pined insulation are not acceptable. Base frame shall be attached to the unit at the factory.

C. Exterior Panels: The exterior panel shall be fabricated from formed 16 gauge G-90 galvanized steel with exterior coating as specified below. The air handling unit casing shall be of the “no-through-metal” design, must have full thermal break. The casing structure shall incorporate insulating thermal breaks as required so that, when fully assembled, there exists no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to 1/200 of the narrowest panel dimension. If panels cannot meet this deflection, add additional internal reinforcing. Panels shall be gasketed and secured to the tubular steel frame with 1/4” hex head, zinc plated fasteners and neoprene washers. Unit frame shall be from 14 gauge carbon tubular steel, mig welded to form a unitized assembly for support of all internal components. Base and unit frame shall be painted with an industrial direct to metal (DTM) finish with built-in rust inhibitors. Outer panels are to be removable without affecting the structural integrity of the unit. All panel seams shall be caulked and sealed for an airtight unit. Leakage rates shall be less than 1% at design static pressure. The exterior panel finish shall be polyester resin paint system that is designed for long term corrosion resistance meeting or exceeding (ASTM B-117) Salt Spray Resistance at 95°F, 1,000 hours and (ASTM D-2247) Humidity Resistance at 95°F, 1,000 hours. The color shall be sterling gray.

D. Double Wall Construction: Each unit shall be double wall construction in all sections and shall have a solid galvanized steel liner.

E. Insulation: Entire unit to be insulated with non-compressed fiberglass insulation. The insulation shall have an effective thermal conductivity (C) of .24 (BTU in./sq.ft.°F) and a noise reduction coefficient (NRC) of 0.70 / per inch thick (based on a type "A" mounting). The coefficients shall meet or exceed a 3.0 P.C.F. density material rating. Insulation shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the exterior panel. Insulation facing the airstream shall be Tuf-Skin with black acrylic coating.

F. Unit shall be painted with industrial grade Polyceram 3200 paint system utilizing a polyester resin that is not sensitive to moisture and remains extremely flexible. The paint system shall contain ceramic pigments for longer lasting color retention and chalking resistance caused by exposure to ultraviolet sunlight. This paint system is designed for maximum resistance to long term corrosion of hot dipped galvanized coated steel and aluminum. It shall provide optimum adhesion, fabrication capability, and abrasion resistance. The industrial coating facility shall have or be in the process of obtaining, ISO 9001 Certification.

2.6 DIRECT DRIVE ARRANGEMENT 4 PLUG FANS

A. Motors:

1. Refer to Section 15170 for additional requirements.
2. Motors shall be factory wired to variable frequency drives (VFD). Refer to Section 15171 for additional requirements for VFD’s.
3. All motors used with VFD’s shall be provided with shaft grounding.
4. Motor removal rails shall be provide for all supply fan motors.

B. Fan performance shall be based on tests run in accordance with AMCA. The wheel diameters shown on the equipment schedule are minimum diameters. Fans shall be horizontal, SWSI, Arrangement #4 direct drive. Fans wheels shall be aluminum with extruded continuously welded air foil blades.
C. Bearings are to be pillow block, self-aligning type, grease-lubricated ball or roller bearings selected for L-10, 200,000-hour life under specified load and speed conditions. Provide bearing selection calculations as part of the submittal process.

D. Fan Volume Control: Fan volume control for VAV application shall be accomplished through the use of a variable speed drive. Variable speed drives shall be of the PWM type as specified under Section 15171.

E. Provide a pressure safety cutoff device across each supply fan cabinet to automatically shut down the fan when pressure differential exceeds 8” w.g.

F. Fan Rotation Protection: Protection of personnel from injury from rotating fan wheels shall be accomplished through the use of a micro switch which, upon opening of the fan section door, will interrupt the control circuit to the VFD controlling the fan motor. Wiring between this micro switch to the starter shall be supplied and installed by the contractor. A threaded rod mechanism device shall be supplied to delay opening the fan section door while the fan is slowing down. Such device and the described micro switch shall be provided for each fan section.

G. Fan Base, Spring Isolation, and Support Framing:
   1. Mount fan and motor on an internal, fully welded, rigid structural steel “C” channel base. Base shall be free floating at all four corners on spring type isolators with earthquake restraints. The fan assembly shall be isolated from the cabinet by steel springs with deflection as indicated in schedules. The fan discharge shall be isolated from the cabinet by means of a neoprene-coated flexible connection. The structure supporting the bearing bar shall be fabricated from structural steel and detachable to allow for removal of the fan wheel and shaft as one piece.
   2. Balancing: The shafting of the fan shall be sized not to exceed 75% of the first critical speed for maximum RPM of Class specified. The critical speed will refer to the top of the speed range of the fans’ AMCA class. The lateral static deflection shall not exceed 0.003" per foot of the length of the shaft. The shaft and wheel shall be dynamically balanced in two planes as a complete unit to a maximum residual unbalance of 0.15 oz., at 95% of the fan radius in each plane. A copy of the above balance test data for this project showing calculations for deflection and critical speed of the shaft and wheel assembly shall be submitted to the engineer.
   3. Motors and Drive: Furnish premium efficiency open drip proof standard NEMA frame rigid ball bearing type motors. Reliance XE, Baldor Super-E, A.O. Smith or equal (no known equal) with grease lubricated bearings and alemite fittings. Horsepower’s as shown on the schedule are minimum allowable.

H. All fans which are to be used in a parallel operation shall be provided with a 100% shutoff device. The shut off device shall include an inner sliding disk at the fan inlet cone, which is positioned from "full open" to "closed." Seals are provided to prevent air leakage around the perimeter contact points. Shaft extensions are provided for for a 2-position actuator.

2.7 MARINE SERVICE LIGHTS

A. Vapor-proof marine lights shall be factory wired to a common switch located next to the supply fan access door for each section requiring access.

B. Supply compact fluorescent lights in all access sections.

C. On units with split sections, provide electrical junction boxes at each split point for field wiring the light circuit connections.
2.8 AIR COILS

A. Chilled water coils shall be the plate fin extended surface type. The primary surface shall be a minimum of 5/8" outside diameter seamless copper with a 0.020" minimum wall thickness. Each coil shall have individually replaceable return bends of 0.025 wall thickness minimum on both sides of the coil. Coils incorporating a "hairpin" type design are not acceptable. Tubes shall be expanded into the fin collars to provide a permanent mechanical bond.

B. The secondary surface shall be flat or formed of 0.008" aluminum fins and shall be spaced not closer than 12 fins per inch with integral spacing collars that cover the tube surface. Headers shall be non-ferrous seamless copper, outside the airstream and provided with tobin bronze brazed steel male pipe connections and 1/8" pipe vent and drain connection.

C. All coils shall be counter-flow construction with connections left or right hand as shown on the drawings. The use of internal restrictive devices to obtain turbulent flow will not be accepted.

D. Casing shall be minimum 16-gauge, 316 stainless steel with double formed 1/2" stacking flanges and 3/4" flanges on the side plates. Flanged tube sheets shall have extruded tube holes. Reinforcing rods shall be furnished so that the unsupported length is not over 60". All coil assemblies shall be tested under water at 300 psi and rated for 150 psi working pressure. Headers are to be located inside the cabinet casing with only the pipe connections extending through the casing.

E. End of coils shall be carefully blanked to ensure all air passes through the coil. Intermediate condensate pans are to be furnished on multiple coil units with copper down tubes to the main drain panel.

F. 316 Stainless steel recessed drain pans shall be provided as an integral part of the unit base in all cooling coil sections. The drain pans shall be sized to encompass the entire coil finned area. Pans shall be 16-gauge minimum with 1"-1½ lb. density, neoprene coated fiberglass insulation and a 16-gauge under liner. Stainless steel condensate connections shall be provided on both sides of the unit.

G. All coils shall be certified in accordance with ARI Standard 410.

2.9 AIR FILTERS

A. All air filters shall be State Fire Marshal approved and listed type. Preformed filters having combustible framing shall be tested as a complete assembly. Air filters in all occupancies shall be Class 2 or better, as shown in the State Fire Marshal listing. Air filters shall be accessible for cleaning or replacement per California Mechanical Code 402.3.

B. Filter sections shall be fabricated as part of the air handling unit. Filters shall be arranged for upstream loading.

C. Provide Burke Environmental Astr-Frame Model ASF-24243, 304SS filter holding frame.

1. Filter holding frames shall be constructed of 16 gage 304 stainless steel and welded construction. Welds shall be continuous on all matching joints and miters. Welds shall be ground to form a smooth surface on the outside periphery of the frame and on the flush mitered joints on the sealing flange of the frame.

2. The frame shall be equipped with various lances to facilitate the use of various types of fasteners depending on the application. The lances shall be designed in such a manner that they can be installed and removed without the use of tools.

3. Frames shall be assembled to form built up filter banks with the use of nuts and bolts and vertical support members.
4. Provide caulking or gasketing between frames, there shall be no metal to metal contact.

D. Provide Aerostar or equal, 2” thick, 40% efficient pre-filters.
   1. Each filter shall consist of 100% synthetic media, heavy gage expanded metal support grid and beverage board enclosing frame.
   2. The filter shall be classified as per ASHRAE 52.2 and shall have a minimum efficiency of 40% on particles that are 1 micron in diameter.
   3. Filters shall be listed by Underwriters Laboratories as Class 2.

E. Provide Aerostar FP-95 or equal, 12” thick, MERV-14 or 95% efficient final filters.
   1. Air filters shall be high efficiency, extended media area, totally rigid and disposable type.
   2. Filter shall be of the quantities and sizes as indicated on the drawings.
   3. The filter media shall be non-shedding, wet process, micro fine glass fiber paper configured in a mini pleat cellular design. The cellular design shall be wedge shaped and shall be arranged in such a manner that dynamic losses are minimized on the air entering and air exiting sides of the filter.
   4. Each 24”x24” filter shall consist of a minimum of 8 mini pleat cells nominal size 12”x24”x1”. The cells shall be assembled and sealed with polyurethane potting forming an airtight and completely disposable filter unit.
   5. Filters shall be listed by Underwriter Laboratories as Class 2 and shall be contained on the California State Fire Marshal approval list.

F. Provide factory installed Dwyer Magnehelic "Series 2000" pressure gauge at each filter bank.
   1. Gauge shall be complete with static pressure tips, hardware and fittings.
   2. Enclose the gauge in a protective sheet metal box with a hinged inspection door. Paint to match unit.

2.10 ECONOMIZER, RETURN AND RELIEF AIR DAMPER SECTION

A. Damper shall be Ruskin heavy duty type Model CD-50 or equal.

B. Dampers shall be:
   1. Extruded aluminum type with rubber edge seals and stainless steel arc end seals.
   2. Low leak and incorporate nylon bearings.
   3. Dampers shall be opposed blade type.
   4. Dampers shall be sized for not greater than 1200 fpm face velocity based upon gross damper area.
   5. Furnish full height 24” wide access doors for damper and linkage service.
   6. Dampers shall be manufactured by the air handling unit manufacturer for single source responsibility.
   7. Economizer section shall include dampers for return air, outside air and relief air and louvers for outside air and relief air.

C. Louvers shall be galvanized steel, 4 inch deep with 45-degree blades and be of the drainable type. Such louvers shall be equipped with drains to allow water to be discharged from the end of each blade and not to a lower louver blade. Louvers shall be suitable for and not exceed face velocities of 500 feet per minute for outside air and 800 FPM for exhaust air. Provide 1/2 inch mesh, 0.04 inch stainless steel wire bird screen in aluminum or galvanized steel frame on all louvers and hoods. Outside air or exhaust air hoods in lieu of louvers are not acceptable. Drain pans shall be supplied for all intake louvers and drained to the outside of the cabinet.
2.11 SOUND ATTENUATORS

A. All ducted inlet and discharge floor openings shall be provided with 5ft vertical sound traps. Sound traps shall be rigidly secured to the floor of the air handling unit. Inlet and discharge plenum lengths shall be sufficient for proper airflow into return fans and leaving supply fans. Sound traps shall be IAC and shall be selected to meet sound performance in Section 2.16.

2.12 MINIMUM OUTSIDE AIR DAMPER AND AIR FLOW MONITORING SECTION

A. The minimum outside air damper section shall be Ruskin Model AML6 or equal.

B. Airflow measuring stationary louver and airflow monitoring station shall be:

1. Damper shall be Ruskin Model CD-40 or equal.
2. Damper shall be constructed of extruded aluminum, 6” thick frame with vertically mounted blades.
3. Damper shall be sized to meet the minimum airflow requirement of 2,000 CFM up to maximum airflow requirement of 9,000 CFM. Louver free area will be sized for 400-2,000 FPM.
4. Each blade shall be provided with total pressure and static pressure measuring chambers.
5. Provide Ruskin RU-274-275 low pressure transducer or equal.

2.13 AIR FLOW MEASURING STATIONS – CFM METER

A. Fans shall be supplied with a complete flow measuring system capable of supplying a 4-20 mA or 0-5 VDC output signal to the EMS system that is proportional to air flow. The flow measuring station and a flow transmitter, both factory mounted and pneumatically piped internal to the unit.

B. The flow measuring station shall be mounted at the entrance of the fan inlet cone with velocity pickup sensors located around the circumference of the cone. Manufacturers unable to provide this type of flow measuring station may provide a cross grid type station to span the entire width and height of the air handling unit as an alternate method of air flow measurement. Devices that obstruct the inlet of the fan (i.e. probes) will not be acceptable. Provide a manegelic gauge with CFM scale on external side of the fan sections which indicates the fan volume.

C. The electronic flow transmitter shall be mounted on the exterior of the fan section. It shall be capable of receiving signals of total and static pressure from a flow element, of amplifying, extracting the square root, and scaling to produce a 4-20 mA DC or 0-5 VDC output signal linear and scaled to air volume or velocity. The flow transmitter shall be capable of the following performance and application criteria.

D. Calibrated spans from 0-896 FPM, in eight flow range increments. Output signal 4-20 mA. DC or 0-5 VDC standard. Integral zeroing means 3-way zeroing valve with manual switch. Temperature effect ± 2.0% of full span from 40°F to 120°F. The transmitter shall not be damaged by over-pressurization up to 200 times greater than span, and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a NEMA 12 enclosure with external signal tubing, power and output signal connections.

E. The electronic transmitter shall be Air Monitor Veltron DPT 2500, Paragon Model FIT-1005D or equal.
2.14 UNIT MOUNTED CONTROLS

A. All controls shall be field installed by the installing temperature controls contractor and coordinated with the new building automation system. These controls shall include all damper actuators, temperature sensors, pressure sensors, air flow measuring sensors, filter switches, smoke and fire detectors as indicated on the control drawings.

B. Electric and electronic controls shall be wired to a terminal block in a sheet metal enclosure located at a common location mounted on the air handling unit. All pressure sensing controls shall be piped to a common point on the unit with ¼” compression fittings.

C. Wiring for chilled water control valves shall be field supplied by the installing contractor. Control valve wiring shall be extended to an external junction box located near the coil connections with the final wiring connection done by the temperature controls contractor. All control valves and piping specialties shall be provided by the temperature controls contractor and/or piping contractor.

D. If the unit requires splitting; junction boxes shall be furnished on each section to allow the control contractor to make final connections in the field. Wiring shall be clearly labeled to allow ease in final interconnections.

E. All controls shall be supplied and installed by the Division 15975 temperature controls contractor. All wiring shall be performed in a U.L. 508 listed shop.

2.15 ELECTRICAL REQUIREMENTS:

A. All AHU and electrical panel wiring shall be performed in a UL 508 listed shop. Provide single source power panels (SSPP’s) that are constructed according to CEC regulations and carry a U.L.508 listing and label. The panel shall include a non-fused main disconnect switch covering all fans in each unit, Motor Starters for constant volume units or VFD’s for variable volume units, and any necessary transformers, Hand–Off–Auto switches, relays and pilot lights for complete operation of the fans in the unit. The single source power panels shall be factory wired to all factory furnished devices such as motors and interlocks.

B. The air handling unit manufacturer, for the purpose of sole source responsibility, shall manufacture all electrical panel assemblies supplied for the air handlers. The air handling unit manufacturer shall be a U.L. 508 listed panel shop.

C. The main control panel shall have access door(s) for direct access to the controls. The panel shall be NEMA type 3R (rainproof) and shall contain a single externally operated, non-fused disconnect, suitable for copper wire up to and including 3” conduit. The electrical contractor shall bring separate 460/3/60 power to the single source power panel.

2.16 UNIT SOUND POWER LEVELS

A. The maximum sound power level at the air handling unit discharge, return air inlet, fresh air inlet, and/or casing radiated shall not exceed the values given in the schedule below, when operating at the maximum design airflow and static pressure conditions.
SOUND POWER LEVELS BY OCTAVE BAND (dB RE: 10 E-12 WATTS)

<table>
<thead>
<tr>
<th>Item</th>
<th>C F M / T.S.P.</th>
<th>Fan Hz</th>
<th>Hz</th>
<th>Hz</th>
<th>Hz</th>
<th>Hz</th>
<th>Hz</th>
<th>Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU-1</td>
<td>56,000 / 6&quot;</td>
<td>Supply Outlet</td>
<td>85</td>
<td>89</td>
<td>83</td>
<td>69</td>
<td>65</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fresh Air Inlet</td>
<td>92</td>
<td>101</td>
<td>101</td>
<td>95</td>
<td>91</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casing Radiated</td>
<td>78</td>
<td>82</td>
<td>79</td>
<td>68</td>
<td>59</td>
<td>51</td>
</tr>
<tr>
<td>AHU-2</td>
<td>35,000 / 5&quot;</td>
<td>Supply Outlet</td>
<td>81</td>
<td>84</td>
<td>76</td>
<td>63</td>
<td>58</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>31,000 / 1.5&quot;</td>
<td>Return Inlet</td>
<td>79</td>
<td>85</td>
<td>72</td>
<td>61</td>
<td>58</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casing Radiated</td>
<td>80</td>
<td>82</td>
<td>78</td>
<td>69</td>
<td>59</td>
<td>52</td>
</tr>
</tbody>
</table>

B. Provide sound power level data for the unit that will be supplied.

2.17 SOUND POWER AND PERFORMANCE CERTIFICATION:

A. Manufacturer shall perform sound test for the units that will be provided for this project in accordance with AMCA Standard 300-96 Reverberant Room Method for sound testing of fans, and AMCA Standard 210, Laboratory Methods of Testing Fans for rating. All testing shall be conducted in a laboratory AMCA certified for both sound and performance.

B. The sound power data shall be submitted for review. Sound power data shall be provided at the supply and return connection in addition to radiated sound power from the cabinet. Raw fan sound power data shall be derived from tests done in accordance with AMCA Standard 300-96. Attenuation assumed for the cabinet configuration, type of insulation, opening locations and sizes, etc., shall be verified through actual test measurements. Provide copy of all test reports.

C. The manufacturer shall notify the College Representative a minimum of ten (10) days prior to test as to the location and date of the sound test for witness. All costs shall be provided by the equipment manufacturer.

D. If sound test indicates noise levels above specified levels, the manufacturer shall take corrective measures to reduce the sound to specified levels. Any modifications that are necessary to meet scheduled sound levels shall be applied to all units. Test results shall be submitted to the College Representative for review prior to shipment of any equipment.

2.18 AIR PERFORMANCE TESTING:

A. The manufacturer shall perform an air performance test on one selected unit in accordance to AMCA 210-85/ANSI 51-1985 “Standard for Laboratory Measurement of Airflow”.

B. Submit air handling unit air performance data to College Representative for review.
C. The manufacturer shall notify the College Representative a minimum of ten (10) days prior to test as to the location and date of the air performance test for witness. All costs shall be provided by the equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances, and other conditions affecting performance of equipment.

B. Verify that roof is ready to receive Work and opening dimensions are as illustrated by the manufacturer.

C. Verify that proper power supply is available.

D. Verify that the required mechanical services are in place.

3.2 INSTALLATION

A. Install air handling units and accessories plumb and level in accordance with manufacturer's instructions.

B. Contractor shall install final filters after construction is complete.

C. Contractor shall replace pre-filter after construction is complete.

3.3 CONNECTIONS

A. Duct installations and connections are specified in other Division 15 Sections.

B. Make final duct connections with flexible connections.

3.4 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust.

C. Vacuum clean entire unit interior, fan wheel, cabinet and coils.

END OF SECTION 15855
SECTION 15870 - FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

   A. This section specifies fans.

1.3 QUALITY ASSURANCE

   A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

   - AMCA 210 Laboratory Methods of Testing Fans for Rating Purposes.
   - AMCA 301 Method of Publishing Sound Ratings for Air Moving Devices.
   - NFPA 70 National Electrical Code.
   - UL 705 Power Ventilators.

1.4 SUBMITTALS

   A. Provide product information per specification Section 15010.

   B. The following information shall be provided the following:

      1. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, sound power levels at rated capacity, and electrical characteristics and connection requirements.

1.5 OPERATION AND MAINTENANCE DATA

   A. Submit under provisions of Section 15010.

   B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.6 EXTRA MATERIALS

   A. Furnish under provisions of Section 15010.

   B. Provide one extra set of belts for each fan.
PART 2 - PRODUCTS

2.1 ALUMINUM ROOF FANS

A. Manufacturer shall be Loren Cook, Greenheck or equal (no known equal).

B. Product Requirements:

1. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
2. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
3. Fabrication: Conform to AMCA 99.
4. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

C. Performance: As scheduled on Drawings.

D. Description:

1. Roof exhaust fans shall be centrifugal belt drive type. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing and shroud shall be constructed of heavy gauge aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
2. The fan housing and shroud shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength. Motors shall be mounted out of the airstream on vibration isolators. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance.
3. A disconnect switch shall be factory installed and wired from the motor compartment for ease of electrical wiring.
4. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide sheaves required for final air balance.

C. Do not operate fans for any purpose, until bearings are lubricated, and fans have been test run under observation.

END OF SECTION 15870
SECTION 15910 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies volume control dampers, backdraft dampers, air turning vanes, flexible duct connections, duct access doors, duct test holes and motorized dampers.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

   NFPA 90A                           Installation of Air Conditioning and Ventilating Systems.
   SMACNA                             Low Pressure Duct Construction Standards.
   UL 33                               Heat Responsive Links for Fire-Protection Service.
   UL 555                              Fire Dampers and Ceiling Dampers.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers and duct access doors. Provide product data for hardware used.

PART 2 - PRODUCTS

2.1 VOLUME CONTROL DAMPERS

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated. “Jiffy” type manual volume dampers will not be acceptable. Provide Durodyne locking quadrant volume control dampers.

B. Fabricate splitter dampers of material same gage as duct to 24 inches size in either direction, and two gages heavier for sizes over 24 inches.

C. Fabricate splitter dampers of single thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/4 inch diameter rod in self aligning, universal joint action flanged bushing with set screw.

D. Fabricate single blade dampers for duct sizes to 12 x 48 inch.

E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

G. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends.

H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.2 BACKDRAFT DAMPERS

A. Manufacturer shall be Ruskin, Greenheck or equal.

B. Gravity backdraft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer’s standard construction.

C. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure; Model BD6 manufactured by Ruskin.

2.3 AIR TURNING VANES

A. Manufacturer shall be Aerodyne or equal.

B. Multi-blade device with blades aligned in short dimension; blades shall have long trailing edges; steel or aluminum construction; with individually adjustable blades, mounting straps.

2.4 DUCT ACCESS DOORS

A. Manufacturer shall be Ventfabrics, Ductmate or equal.

B. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.

C. Review locations prior to fabrication.

D. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

E. Access doors smaller than 12 inches square may be secured with sash locks. Access doors with sheet metal screw fasteners are not acceptable.

F. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.

G. Access doors in round ducts shall be Ductmate, United Sheet Metal Type AR-W Peabody, Wind Spiromatic or Spiro-Duct or equal (no known equal).
2.5 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions.

B. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.

C. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Provide air turning vanes for all rectangular and square duct elbows.

E. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated.

F. Provide duct test holes where indicated and required for testing and balancing purposes.

END OF SECTION 15910
SECTION 15930 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies pressure independent variable air volume boxes, hot water reheat coils and factory furnished bottom access door.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

   NFPA 90A                  Installation of Air Conditioning and Ventilation Systems.
   UL 181                    Factory-Made Air Ducts and Connectors.

   B. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

   C. Air terminals shall be certified under ARI Standard 880-94 Certification Program and carry the ARI Seal.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit:

   1. Shop drawings indicating configuration, general assembly, and materials used in fabrication.
   2. Product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and NC designation, computer generated hot water reheat coil selections meeting design conditions indicated on plans.
   3. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of one to 4 inch wg.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 15010.

1.5 WARRANTY

A. Provide one year manufacturer's warranty under provisions of Section 15010.

B. Warranty: Include coverage of operating controls and electric motors.
PART 2 - PRODUCTS

2.1 MANUFACTURER
   A. Manufacturer shall be Titus, Krueger or Anemostat.

2.2 GENERAL
   A. Ceiling mounted variable air volume (VAV) supply air control terminals for connection to low pressure duct, central air systems, with variable volume controls, and hot water heating coils as indicated on Drawings.
   B. Identify each airflow unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory set air flow, minimum factory set air flow, and coil type.
   C. Manufacturer shall provide VAV Box flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay and SCR. Manufacturer shall factory install, wire and tube ASC controller and actuator. Mechanical Contractor shall be fully responsible to coordinate all requirements with the Controls Contractor.

2.3 FABRICATION
   A. Casings: Units shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 22-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet) side and unit casing. Provide ultra low leakage construction option.
   B. Insulation shall be double wall type. The interior surface of the unit casing shall be thermally lined with a minimum 1 inch, 0.75 lb./cu. ft. density glass fiber with a high density facing. The insulation R-Value shall be a minimum of 1.9. Insulation shall meet NFPA-90A and UL 181 requirements. The insulation is covered by aluminum foil with perforated metal liner. The interior perforated metal liner shall isolate the fiberglass insulation from the airstream and allow for cleaning of the terminal unit interior surfaces. All wire penetrations through the interior metal liner shall be covered by grommets.
   C. Assembly: Primary air control damper, airflow sensor, fans, controls and optional heating coil in single cabinet.

2.4 PRIMARY AIR CONTROL DAMPER ASSEMBLY
   A. Locate primary air control damper assembly inside unit casing with self-lubricating bearings. Construct the damper assembly from extruded aluminum and/or a minimum 20 gauge galvanized steel components. Maximum damper leak rate shall not exceed 1% of damper nominal CFM at 4 inch water gauge differential pressure.
   B. Provide damper assembly with integral flow sensor. Flow sensor shall be provided regardless of control type. Flow sensor shall be a multi-point, averaging, ring or cross type.
2.5 HEATING COILS
   A. Coil shall be factory-installed and shall consist of aluminum plated fins and seamless copper tubes.
   B. Fins shall have full fin collars to provide accurate fin spacing and maximum fin-to-tube contact. Tubes shall be mechanically expanded into the fin collars. Coils shall be leak tested under water to 450 psig pressure.
   C. Capacity, number of rows and circuits: As scheduled on Drawings.

2.6 WIRING
   A. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source. Provide toggle disconnect switch and 120 volt to 24 volt transformer in each air terminal control box.

2.7 CONTROLS
   A. Air terminal unit shall be automatically controlled from an electronic temperature control system utilizing 24-volt electric control system.
   B. Manufacturer shall provide VAV Box flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay and SCR. Manufacturer shall factory install, wire and tube ASC controller and actuator. Mechanical Contractor shall be fully responsible to coordinate all requirements with the Controls Contractor.

2.8 TESTS
   A. Test run volume dampers and controls. Check sequence of operation and air flow limits at factory prior to shipment.
   B. Maximum Casing Leakage: 7 cfm at 1.5 inch inlet static pressure.
   C. Maximum Damper Leakage: 5 cfm at 1.5 inch inlet static pressure.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Provide ceiling access doors or locate units above easily removable ceiling components.
   C. Support units individually from structure. Do not support from adjacent ductwork. Refer to 2001 CMC and SMACNA manuals for support details. Refer to specification Section 15245 and drawings for additional requirements.
   D. Connect to ductwork in accordance with Section 15890.
E. Provide minimum 4’-0” long plenum at discharge side of VAV box with 2” think internal insulation. Refer to Section 15290 for internal liner requirements. Plenum dimension shall be same as VAV box discharge air opening.

F. Install heating coils in accordance with Drawings.

G. Field install variable air volume direct digital controller which is compatible with direct digital control system in accordance with Section 15975. The mechanical contractor shall be responsible to coordinate all controls work with the controls contractor.

3.2 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to minimum flow. Set units with heating coils per schedules on Drawings.

END OF SECTION 15930
SECTION 15936 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies supply air diffusers, return air grilles and exhaust air grilles.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

ADC 1062 Certification, Rating and Test Manual.
ASTM D117 Corrosive Environments
ASTM 870 Water Immersion Test
ASTM D-2794 Reverse Impact Cracking Test
NFPA 90A Installation of Air Conditioning and Ventilating Systems.
ASHRAE 70 Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

B. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

C. Conform to NFPA 90A.

1.3 SUBMITTALS

A. Submit under provisions of Division 1.

B. Refer to Section 15010, 1.10 for additional requirements.

C. The following information shall be provided the following:

1. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level. Manufacturer shall provide detailed performance data, which shows clearly that the diffuser will meet the design requirements.

2. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.

D. The manufacturer shall include a written statement that the submitted equipment, hardware or accessory complies with the requirement of this specification. The manufacturer shall resubmit this specification section showing compliance with each respective paragraphs and specified items and features in this specification. All exceptions shall be clearly identified by referencing respective paragraph and other requirements along with proposed alternative.

E. Whenever more than one (1) manufacturer’s product is specified, the first named product is the basis of design used in the Work and the use of alternate-named manufacturer’s products or substitutes may
require modifications in that design. If such alternatives are proposed by the Contractor, there may be additional design work required. Within 15 days of the submittal of a proposed alternate, as presented in the Contractor’s submittal, the College Representative will provide the design fees to modify the issued drawings and obtain DSA approvals for the work to incorporate that alternate into the documents as required. The contractor shall assume all costs required to make necessary revisions and modifications to the design, including all professional fees to the Architect and Engineers for the evaluation and revisions or modifications of the documents resulting from the substitution or selection of an alternate manufacturer submitted by the Contractor.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSER (CD-1)
   A. Manufacturers shall be Titus Omni, Krueger or Anemostat.
   B. Steel, flush face, square neck, star pattern, perforated face for tee-bar ceilings. A square inlet shall be an integral part of the frame assembly and a transition piece shall be provided to facilitate attachment of round duct.
   C. Provide frame type as indicated on Drawings.
   D. Fabricate of steel with baked enamel off-white finish. Diffuser finish shall be white, anodic acrylic paint baked onto the aluminum and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.

2.2 CEILING DIFFUSER (CD-2)
   A. Manufacturers shall be Titus MCD, Krueger or Anemostat.
   B. Supply air ceiling diffuser shall be steel, modular core and horizontal discharge pattern for lay-in tee bar and surface mount application.
   C. Diffuser shall be provided with square inlet integral to the frame assembly. The inner core assembly must be removable in the field without tools for easy installation and cleaning.
   D. Diffuser finish shall be white, powder coat and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.
   E. Provide with square to round neck transition piece to facilitate attachment to round duct.

2.3 RETURN GRILLE (RG-1)
   A. Manufacturers shall be Titus PXP, Krueger or Anemostat.
   B. Return air grille shall be steel, flush face, for lay-in tee bar or surface application. The grille shall have a perforated face with 3/16” diameter holes on 1/4” staggered centers and no less than 51% free area.
   C. Diffuser finish shall be white, anodic acrylic paint baked onto the aluminum and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.
2.4 EXHAUST GRILLE (EG-1)

A. Manufacturers shall be Titus PAR, Krueger or Anemostat.

B. Grille shall be constructed from one piece heavy gauge steel with flush face, perforated 3/16-inch diameter holes on 1/4 inch staggered centers and no less than 51 percent free area.

C. Grille shall be white, anodic acrylic paint baked onto the aluminum and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.

2.5 EXHAUST GRILLE (EG-2)

A. Manufacturers shall be Titus 4FL, Price, Krueger or Anemostat.

B. Grille shall be aluminum, 1/2” blade spacing at 45° deflection. The blades shall be parallel to the long dimension of the grille. The grille shall be constructed of steel with a 1-1/4” wide border on all sides.

C. The deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be firmly held in place by mullion from behind the grille and fixed in place by crimping and welding.

D. Grille finish shall be white, powder coat and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.

2.6 SIDEWALL REGISTER (SR-1)

A. Manufacturers shall be Titus 300 RS, Krueger or Anemostat.

B. Register shall be steel, 3/4” blade spacing at 45° deflection. The blades shall be parallel to the short dimension of the grille. The grille shall be constructed of steel with a 1-1/4” wide border on all sides.

C. The deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be firmly held in place by mullion from behind the grille and fixed in place by crimping and welding.

D. Diffuser finish shall be white, powder coat and must conform to ASTM D117, ASTM 870 and ASTM D-2794 requirements.

E. Provide integral damper.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturers’ instructions.

B. Install diffusers, registers and grilles in accordance with manufacturer's recommendations, and in accordance with the SMACNA HVAC Duct Construction Standards - Metal and Flexible.
C. Provide balancing dampers on all duct take-off to all grilles and diffusers without exception. Balancing dampers shall not be installed in grease exhaust ductwork.

D. Paint ductwork flat black that are visible behind air outlets and inlets.

END OF SECTION 15936
SECTION 15975 – DIRECT DIGITAL CONTROLS

PART 1 - GENERAL

1.1 SCOPE

A. This section contains general requirements for all work to be provided by the Direct Digital Controls Contractor.

B. Work Specified in this Section:
   1. The control system shall be Automated Logic Control (ALC) system WebCTRL product line per University standards.
   2. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless the University’s Representative approves use of multiple manufacturers.
   3. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.
   4. The control system shall be as indicated on the drawings and described in the specifications, and consist of a high speed peer-to-peer network of digital building control panels and operator workstation.
      a. The operator workstation shall be a personal computer (PC) including a color monitor, mouse and keyboard.
      b. The PC shall provide users an interface with the system through dynamic color graphics of building areas and systems.
   5. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of systems defined for control on this project.
   6. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited by operator password. An operator shall be able to log onto any workstation of the control system and have access to all designated data.
   7. The control system shall be designed such that each mechanical system will operate under standalone control. As such, in the event of a network communication failure, or the loss of other controllers, the control system shall continue to independently operate the unaffected equipment.
   8. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. A modem or network communications card shall be provided to for remote access to the system.
   9. Monitoring and remote start/stop and remote setpoint adjust control of, chillers, cooling towers, pumps and other items included in this section and as shown on the Drawings.
   10. Furnish and install local instrumentation which includes temperature sensors, averaging temperature sensors, water flow sensors, air flow sensors, differential pressure sensors, differential pressure switches, flow switches, automatic switches, mounting hardware and other material as required for a fully functional system.
   11. Furnish and install control valves with actuators, thermowells and flow meters.
   12. Furnish and install automatic dampers indicated on drawings and actuators including necessary linkages, wire, and power wiring.
   13. Coordinate and select locations for mounting all thermowells, sensors, switches, and transmitters.
   14. Furnish and program all software including color graphics.
   15. The controls contractor shall be fully responsible to provide all wiring (low voltage, 120 volts and above) and conduit (3/4” minimum or as required by electrical codes) for connection of all associated ddc sensors, panels, valves, and any other DDC components for a completely operational DDC system.
1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. Drawings and general provisions of the Contract, including General and supplementary Conditions apply to work of this section.

B. Products furnished but not installed under this section:
   1. Control valves, flow meters, flow switches, flow sensors, thermowells and pressure taps to be installed by Mechanical contractor.
   2. Automatic dampers and duct smoke detectors to be installed by Mechanical Contractor.
   3. The Control Contractor shall provide a complete installation for the project with any devices or installations provided by others to be defined with sufficient clarity to provide coordination and verification. There should be no exclusions.

C. Products not furnished or installed by but integrated with the work of this section:
   1. Central plant equipment such as chillers, cooling towers, etc:
      a. Units shall be furnished configured to accept control inputs from an external building automation system controller as specified in this section.
      b. Factory mounted safeties and other controls shall not interfere with this controller.
   2. Air handling units:
      a. Units shall be furnished configured to accept control inputs from an external building automation system controller as specified in this section.
      b. Factory mounted safeties and other controls shall not interfere with this controller.
   3. Air terminal units:
      a. VAV Terminal Units shall be furnished configured to accept control inputs from an external building automation system controller as specified in this section.
      b. Factory mounted safeties and other controls shall not interfere with this controller.
   4. Static power equipment:
      a. Variable frequency drives (VFD) vendor shall furnish VFDs with an interface to the control and monitoring points specified in this section. These specified points shall be the minimum acceptable interface to the VFD. The connection to these points shall be by one of the following methods:
         1) Hardwired connection such as relay, 0-10VDC, or 4-20mA
         2) BACnet/IP network connection
         3) BACnet over ARCNET network connection
         4) BACnet MS/TP network connection.
   5. Communications with third party equipment:
      a. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a BACnet interface for integration into the Direct Digital Control System described in this section.

1.3 QUALITY ASSURANCE

A. System Installer Qualifications
   1. The Installer shall have an established working relationship with the Control System Manufacturer of not less than five years.
   2. The Installer shall have successfully completed Control System Manufacturer's classes on the control system. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.
   3. The installer shall have an office within [50] miles of the project site and provide [24-hour] response in the event of a customer call.
1.4 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of local, state and federal authorities. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Mechanical Code (IMC)
4. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
5. ANSI/ASHRAE Standard 135-2004 (BACnet)
6. ANSI/EIA/CEA-709.1 (LonTalk)

1.5 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. The system shall display a graphic with a minimum of twenty 20 dynamic points with current data displayed within 10 seconds of the request.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 15 seconds.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 seconds.
4. Object Command. Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 18 seconds.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Performance. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
8. Multiple Alarm Annunciations. All workstations on the network shall receive alarms within 5 seconds of each other.
9. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Reported Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature</td>
<td>±0.5°C [±1°F]</td>
</tr>
<tr>
<td>Ducted Air</td>
<td>±1.0°C [±2°F]</td>
</tr>
<tr>
<td>Outside Air</td>
<td>±1.0°C [±2°F]</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>±0.5°C [±1°F]</td>
</tr>
<tr>
<td>Delta-T</td>
<td>±0.15°C [±0.25°F]</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Water Flow</td>
<td>±5% of full scale</td>
</tr>
<tr>
<td>Air Flow (terminal)</td>
<td>±10% of reading</td>
</tr>
<tr>
<td>Air Flow (measuring stations)</td>
<td>±5% of reading</td>
</tr>
</tbody>
</table>
### Air Pressure (ducts)

±25 Pa [±0.1 "W.G."

### Air Pressure (space)

±3 Pa [±0.01 "W.G."

### Water Pressure

±2% of full scale *Note 2

### Electrical Power

± 1% of reading *Note 3

### Carbon Dioxide (CO₂)

± 50 ppm

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**Table 2**

**Control Stability and Accuracy**

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
<th>Range of Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pressure</td>
<td>±50 Pa (±0.2 in. w.g.)</td>
<td>0-1.5 kPa (0-6 in. w.g.)</td>
</tr>
<tr>
<td></td>
<td>±3 Pa (±0.01 in. w.g.)</td>
<td>-25 to 25 Pa (-0.1 to 0.1 in. w.g.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0-1.5 kPa (0-6 in. w.g.)</td>
</tr>
<tr>
<td></td>
<td>±10% of full scale</td>
<td></td>
</tr>
<tr>
<td>Airflow</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±1.0°C (+2.0°F)</td>
<td></td>
</tr>
<tr>
<td>Space Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±1.5°C (+3°F)</td>
<td></td>
</tr>
<tr>
<td>Duct Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±5% RH</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Pressure</td>
<td>±10 kPa (±1.5 psi)</td>
<td>MPa (1-150 psi)</td>
</tr>
<tr>
<td></td>
<td>±250 Pa (±1.0 in. w.g.)</td>
<td>0-12.5 kPa (0-50 in. w.g.) differential</td>
</tr>
</tbody>
</table>

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1.6 SUBMITTALS

A. Refer to Specification Section 15010 for additional requirements.

B. Contractor shall provide shop drawings and manufacturers’ standard specification data sheets on all hardware and software to be provided.
   1. No work may begin on any segment of this project until the University’s Representative has reviewed submittals for conformity with the plan and specifications.
   2. Six (6) copies are required.
   3. All shop drawings shall be provided to the University electronically as .dwg or .dxf file formats.

C. Quantities of items submitted shall be reviewed by the University’s Representative. Such review shall not relieve the contractor from furnishing quantities required for completion.

D. Provide the University’s Representative, any additional information or data which is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.

E. Submit the following within [60] days of contract award:
   1. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
   2. A schedule of all control valves including the valve size, model number (including pattern and connections), flow, CV, pressure rating, and location.
   3. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.
   4. Provide manufacturers cut sheets for major system components. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature
and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:

a. Building Controllers
b. Custom Application Controllers
c. Application Specific Controllers
d. Operator Interface Computer(s)
e. Portable Operator Workstation
f. Auxiliary Control Devices
g. Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling
h. Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled
i. Points list showing all system objects, and the proposed English language object names
j. Sequence of operations for each system under control. This sequence shall be specific for the use of the Control System being provided for this project
k. Color prints of proposed graphics with a list of points for display

F. Project Record Documents. Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

1. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .DWG or .DXF drawing files shall also be provided.
2. Testing and Commissioning Reports and Checklists.
3. Operating and Maintenance (O & M) Manual. These shall be as-built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:
   a. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
   b. Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
   c. Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.
   d. Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
   e. A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
   f. One set of electronic media containing files of all color-graphic screens created for the project.
   g. Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.
   h. Complete original issue media for all software provided including operating systems, programming language, operator workstation software, and graphics software.
   i. Licenses and warranty documents for all equipment and systems.
   j. Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.

G. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The University reserves the right to modify any or all of the training course outline and training materials. Review and approval by University and Engineer shall be completed at least 3 weeks prior to first class.
1.7 WARRANTY

A. Warrant all work as follows:
   1. Labor & materials for control system specified shall be warranted free from defects for a period of
      twelve (12) months after final completion acceptance by the University. Control System failures
      during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in
      service to the University. The Contractor shall respond to the University’s request for warranty
      service within 24 hours during customary business hours.
   2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the
      University and Engineer, the University shall sign certificates certifying that the control system's
      operation has been tested and accepted in accordance with the terms of this specification. The
      date of University’s acceptance shall be the start of warranty.
   3. Operator workstation software, project specific software, graphics, database, and firmware updates
      shall be provided to the University at no charge during the warranty period. Written authorization
      by University must, however, be granted prior to the installation of such changes.
   4. The system provider shall provide a web-accessible system and support on-line resource that
      provides the University access to a question/answer forum, graphics library, user tips, upgrades,
      and manufacturer training schedules.

1.8 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become the University's property. This includes, but is
   not limited to:
   1. Graphics
   2. Record drawings
   3. Database
   4. Application programming code
   5. Documentation

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The control system shall be Automated Logic Control (ALC) system WebCTRL product line per
   University standards.

2.2 MATERIALS

A. All products used in this installation shall be new, currently under manufacture, and shall be applied in
   similar installations for a minimum of 2 years.
   1. The installation shall not be used as a test site for any new products unless explicitly approved by
      the University’s representative in writing.
   2. Spare parts shall be available for at least 5 years after completion of this contract.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a
   BACnet internetwork. Controller and operator interface communication shall conform to ASHRAE/ANSI
B. Install new wiring and network devices as required providing a complete and workable control network. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
   2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in this section. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
   1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
   2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
   3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.
   4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.4 OPERATOR INTERFACE

A. Operator Interface.
   1. Furnish 1 PC based workstation for installation in the Satellite Cooling Plant.
   2. Workstation shall be able to access all information in the system.
   3. Workstation shall reside on the same high-speed network as the building controllers, and also be able to dial into the system.

B. Workstation information access shall use the BACnet Protocol.
   1. Communication shall use the ISO 8802-3 (Ethernet) Physical/Data Link layer protocol.
   2. Remote communications shall use the BACnet Point to Point Physical/Data Link Layer Protocol.
C. Hardware. Each operator workstation shall consist of the following:
   1. Personal Computer.
      a. Furnish IBM-compatible PCs to be used as DDC system workstation.
      b. The CPU shall be latest version Intel Pentium processor and operate at a minimum 2.6 GHz.
      c. Provide minimum 2 Gigabytes of RAM, 48X CD ROM drive, 120 Gigabyte hard disk, and two-button mouse.
      d. Furnish all required serial, parallel, and network communication ports, and all cables for proper system operation.
      e. The PC shall include a minimum 20", color monitor with 1024 x 768 screen resolution.

D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:
   1. Log In and Log Out. System shall require user name and password to log in to operator interface.
   2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
   3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
   4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
   5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
   6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
   7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
   8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
   9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. System Software
   1. Operating System.
      a. Furnish a commercially available, concurrent multi-tasking operating system.
      b. Acceptable operating systems are Microsoft Windows XP Professional.
      a. The Operator Workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status.
      b. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while the system is on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files.
      c. Graphics shall have the ability to show animation of equipment. Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions (V17). Graphics shall be capable of launching other PC applications.
3. Custom Graphics. Custom graphic files shall be created with the use of commonly available graphics packages such as Corel Paint Shop Pro. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as BMP, GIF and JPEG.

4. Graphics Library. Furnish a complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators, including 2-dimensional and 3-dimensional graphic depictions. The library shall include a minimum of 300 such files available for use by the University. This library shall also include standard graphical representations of equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

5. Engineering Units. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system. Unit selection shall be able to be customized by locality to select the desired units for each measurement. Engineering units on this project shall be Inch Pound.

6. Furnish Graphics as listed below:
   a. (1) per each piece of mechanical equipment (Chiller, AHU, etc.)
   b. (1) per each mechanical system (chilled water, condenser water, hot water, etc.).
   c. (1) Main starting point graphic showing site layout with navigation buttons to all other graphics.
   d. (1) Floor plan graphics per floor showing mechanical equipment.

F. System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation.

1. Automatic System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each building controller. This database shall be updated whenever a change is made in any panel in the system. The storage of this data shall be automatic and not require operator intervention. In the event of a database loss in a building management panel, the first workstation to detect the loss shall automatically restore the database for that panel.

2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database from any system panel and store on magnetic media. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

3. System Configuration. The workstation software shall provide a graphical method of configuring the system. The user with proper security shall be able to add new devices, and assign modems to devices. This shall allow for future system changes or additions.

4. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all system functions and shall provide the relevant data for that particular screen. Additional help shall be available through the use of hypertext links onscreen.

5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set security levels for all other operators. Each operator password shall be able to restrict the operator’s access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format.

6. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

7. Alarm Notification. Alarm messages shall use full language, easily recognized descriptors for alarm. System shall allow the user to have up to 10 popup windows appear for incoming alarms. The popup dialog shall allow the user to silence and acknowledge alarms, view an expanded message or graphic, and add and save comments for the alarm.

8. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
9. Alarm Reactions. The operator shall be able to determine what actions, if any, are to be taken, by object, during an alarm. Actions shall include logging, printing, start a custom control program, displaying messages, dialing out to remote workstations, paging or text message to a cell phone, forwarding to an e-mail address, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. An object in alarm that has not been acknowledged within an operator specified time period shall be re-routed to an alternate operator specified alarm receipt device. For text messaging, the system shall support TAP protocol including parities 7-E-1 and 8-n-1, such that if the system fails to dial out/connect with one parity it will automatically try the other one.

10. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in up to 5 color-coded categories based on University preference (V17). Include an alarm count summary for each alarm category on the system toolbar. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation. Provide a comment field in the event log that allows a user to add specific comments associated with any alarm.

11. Trend Logs. The operator shall be able to define a trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals of 30 seconds, 1, 5, 15, 30, and 60 minutes as well as once a shift (8 hours), once a day, once a week, and once a month shall be selectable. Each trend shall accommodate up to 64 system objects. The system operator shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel and be archived on the workstation hard disk. Trend data shall be able to be viewed and printed from the operator interface software. Trends must be viewable in a text-based format or graphically. Trends shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.

12. Dynamic Graphical Trending. The system shall have the ability to save the data collected by a trend object and display that collected data in a graphical chart. Trend viewing capabilities shall include the ability to show up to 10 points on a chart, to include live and/or historical data. Each data point trend line shall be an individual color, and include on-graph icons that represent associated events/alarms, manual overrides, and automated changes that have occurred over the time frame represented on the chart. Navigation and viewing functions shall include scrolling and zooming of x and y axes, and a trace display of the associated time stamp, and values for any selected point along the x-axis. Trend data shall be able to be stored for up to 10 years on the PC workstation.

13. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics or through custom programs.

14. Clock Synchronization. The real time clocks in all building controllers and workstations shall be synchronized on command of an operator. The system shall also be able to automatically synchronize all system clocks; daily from any operator designated device in the system. The system shall automatically adjust for daylight savings time if applicable.

15. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals. Provide a means to list and access the last 10 reports viewed by the user.
   a. Custom Reports: Provide the capability for the operator to define any system data into a daily, weekly, monthly, or annual report. These reports shall be time and date stamped and shall contain a report title.
   b. Standard Reports. The following standard system reports shall be provided for this project. These reports shall be readily customized to the project by the University.
1) Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand for each building meter. Provide an annual (12 month) summary report showing the monthly electrical consumption and peak demand for each meter.

2) All Points in Alarm Report: Provide an on demand report showing all current alarms.

3) All Points in Override Report: Provide an on demand report showing all overrides in effect.

4) Schedule Report: Provide a summary of all schedules including Holiday and Exception schedules.

5) Commissioning Report: Provide a one time report that lists all equipment with the unit configuration and present operation.

6) Gas Meter Report: Provide a monthly report showing the daily natural gas consumption for each meter. Provide an annual (12 month) report that shows the monthly consumption for each meter.

7) Weather Data Report: Provide a monthly report showing the daily minimum, maximum and average outdoor air temperature and the number of heating and cooling degree days for each day. Provide an annual (12 month) report showing the minimum, maximum and average outdoor air temperature for the month and the number of heating and cooling degree days for the month.

8) ASHRAE Standard 147 Report: Provide a daily report that shows the operating condition of each chiller as required by ASHRAE Standard 147. At minimum this report shall include:
   a) Chilled Water (or other fluid) inlet and outlet temperature
   b) Chilled Water (or other fluid) flow
   c) Chilled Water (or other fluid) inlet and outlet pressures
   d) Evaporator refrigerant pressure and temperature
   e) Condenser refrigerant pressure and liquid temperature
   f) Condenser water inlet and outlet temperatures
   g) Condenser water flow
   h) Oil pressure and temperature
   i) Oil level (if applicable)
   j) Compressor refrigerant discharge temperature
   k) Compressor refrigerant suction temperature
   l) Manual entry field for addition of refrigerant
   m) Manual entry field for addition of oil
   n) Manual entry field for vibration levels
   o) Motor amperes per phase
   p) Motor volts per phase
   q) Purge exhaust time or discharge count
   r) Ambient temperatures (dry bulb and wet bulb)
   s) Date and time data logged

G. Workstation Applications Editors. Each PC workstation shall support dedicated screens for editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at the appropriate controller panels.

1. Controller. Provide a full screen editor for each type custom application, and application specific controller that shall allow the operator to view and change the configuration, name, control parameters, and system set-points.

2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. An advance and delay time for each object shall be adjustable from this master schedule. An
operator shall be able to modify the schedule. Schedules shall be able to be easily copied between objects and/or dates.

3. Manual Control and Override. Provide a means of manually controlling analog and binary output points. Control overrides shall be performed through a simple, graphical on-off-auto editor for binary points, and auto-manual selector for analog control. Provide a icon indicator of override status when a point, unit controller or application has been overridden manually.

4. Air System Equipment Coordination. Provide editor screens with monitoring and control functions that group together and coordinates the operation of air handling equipment as specified in the sequence of operations. For each air system, the editor pages shall include:
   a. System mode of the air handling system
   b. Listing and assignment of the associated air handler
   c. AHU supply air cooling setpoints
   d. AHU nominal static pressure setpoints

5. Chiller System. A chiller plant control application shall be configured using a full screen editor and shall provide operating status for the system. The display shall include:
   a. System mode of the chiller plant
   b. Chiller enable/disable status
   c. System supply water setpoint
   d. System supply and return water temperature
   e. System Chilled water pump status
   f. System Chilled water flow
   g. Bypass pipe flow rate
   h. Messages as to when an additional chiller will be added or removed from operational sequence
   i. Chiller or system failure information
   j. Chiller rotation information
   k. Override capabilities to force an added chiller, subtract a chiller, or change of sequence.
   l. Control to remove a chiller from a sequence temporarily for service purposes.

H. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.

2.5 APPLICATION AND CONTROL SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator workstation.

B. System Security

1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to only the objects, applications, and system functions as assigned by the system manager.
3. User logon/logoff attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
C. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:

1. Weekly Schedule. Provide separate schedules for each day of the week.
2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
3. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
4. Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

D. Remote Communications. The system shall have the ability to transmit alarms to multiple associated alarm receivers. Receivers shall include PC Workstations, email addresses, cell phones and alphanumeric pagers. The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system utilizing the system Ethernet communications, or dial up communications via modem, in the same format and method used on site as described under the Operator Interface section of this specification.

E. Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts, and/or calendar date limits.

F. Chiller Sequencing. Provide applications software to properly sequence the chiller plant to minimize energy use. This application shall perform the following functions:

1. The chiller plant control application shall have the ability to control multiple chillers as detailed in the sequence of operations.
2. This application shall be able to control both variable flow systems as well as parallel, series and decoupled piping configurations.
3. Diagnostics/Protection - The chiller plant application program shall be able to integrate individual chiller diagnostics into control action decisions.
4. Event Processing - All chiller plant control and status events shall be recorded, at the operator’s selection, in the building management system event log to facilitate troubleshooting.
5. Alarm Indications - The chiller plant control status screens shall display chiller plant and individual chiller alarm messages.
6. Add/Subtract actions - The status screens shall provide information on when the next chiller add or subtract action will occur. The operator shall have the ability to manually force a chiller addition or a chiller subtraction.

G. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-wind-up shall be supplied. The algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs. The controlled variable, set-point, and PID gains shall be user-selectable. The set-point shall optionally be chosen to be a reset schedule.
H. Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, workstation, or the operator display. The amount of time that the override takes precedence will be selectable from the workstation.

I. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.

J. System Calculations. Provide software to allow instantaneous power (e.g. KW), flow rates (e.g. L/s [GPM]) to be accumulated and converted to energy usage data. Provide an algorithm that calculates a sliding-window KW demand value. Provide an algorithm that calculates energy usage and weather data (heating and cooling degree days). These items shall all be available for daily, previous day, monthly and the previous month.

K. Anti-Short Cycling. All binary output points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

2.6 BUILDING CONTROLLERS

A. General. Provide Building Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

   1. The Building Automation System shall be composed of one or more independent, standalone, microprocessor based Building Controllers to manage the global strategies described in System software section.
   2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.
   3. The controller shall provide a communications port for connection of the Portable Operators Terminal.
   4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
   5. Controllers that perform scheduling shall have a real time clock.
   6. Data shall be shared between networked Building Controllers.
   7. The Building Controller shall utilize industry recognized open standard protocols for communication to unit controllers.
   8. The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

      a. Assume a predetermined failure mode.
      b. Generate an alarm notification.
      c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.
      d. Automatically reset the Building Controller to return to a normal operating mode.

B. Communications. Each Building Controller shall reside on a BACnet internetwork using the ISO 8802-3 (Ethernet) Physical/Data Link layer protocol. Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers. Each Building Controller shall perform communications to a network of Custom Application and Application Specific Controllers using LonTalk FTT-10 and LonMark profiles.
C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at 32 F to 120 F.

D. Serviceability. Provide diagnostic LEDs for power, communications, and processor. The Building Controller shall have a display on the main board that indicates the current operating mode of the controller. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable. The primary logic board shall be removable without disconnecting field wiring.

E. Memory. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage.

2.7 CUSTOM APPLICATION CONTROLLERS

A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. Controllers that perform scheduling shall have a real time clock.
3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. The 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. Custom application controllers shall communicate using LonTalk. Controllers shall use FTT-10 transceivers. All communications shall be with the use of LonMark-approved SNVTs.

B. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient shall be mounted in NEMA 1 type enclosures, and shall be rated for operation at 32 F to 120 F.
2. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 158 F.

C. Serviceability. Provide diagnostic LEDs for power, communications, and processor. All low voltage wiring connections shall be made such that the controller electronics can be removed and/or replaced without disconnection of field termination wiring.

D. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

E. 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.
2.8 APPLICATION SPECIFIC CONTROLLERS

A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.

1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each ASC will contain sufficient I/O capacity to control the target system.

B. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient spaces shall be mounted in NEMA 1 type rated enclosures. Controllers located where not to be disturbed by building activity (such as above ceiling grid), may be provided with plenum-rated enclosures and non-enclosed wiring connections for plenum cabling. All controllers shall be rated for operation at 32 F to 120 F.
2. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 150 F.

C. Serviceability. Provide diagnostic LEDs for power and communications. All wiring connections shall be clearly labeled and made to be field removable.

D. Memory. The Application Specific Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.

E. 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%.

F. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.

G. Application Specific Controllers shall communicate using LonTalk. Controllers shall use FTT-10 transceivers. All communications shall follow LonMark profiles. ASCs which do not have a profile that applies must comply with LonMark standards, utilize SNVTs for all listed points, and be provided with a XIF file for self-documentation.

2.9 INPUT/OUTPUT INTERFACE

A. Hard-wired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 3 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.
E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 ma), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

F. Binary outputs shall provide for on/off operation. Terminal unit and zone control applications may use 2 outputs for drive-open, drive-close (tri-state) modulating control.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device.

2.10 SENSORS AND MISCELLANEOUS DEVICES

A. Temperature Sensors

1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.
2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 5 feet in length.
3. Water immersion sensor with stainless steel thermowell shall be available as a 100 Ohm temperature transmitter. The temperature transmitter us as a platinum RTD sensor and have an output of 4-20 mA. Stainless steel thermowell enclosures shall be weatherproof that repels moisture and condensation
4. Space sensors shall be equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings.
5. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.2 F.
6. Outside air temperature sensor shall be sheathed in stainless steel tube and mounted inside a ventilated, treated, which PVC sunshield to minimize the effect of ambient conditions. The sunshield shall be mounted on a weatherproof outlet box for easy installation on an outdoor surface.

B. Static Pressure Sensors

1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.

C. Current Sensing Relays: Provide solid-state sensor, which operates when the current level sensed by the internal current transformer, exceeds the adjustable trip point. The internal circuits shall be totally powered by induction from the line being monitored. The relay shall have zero off state leakage in the solid-state output while switching both AC and DC circuits. The monitored AC circuits shall be 1 to 150 amps.

1. Water Pressure:
   a. Dwyer #630 series.
   b. Robinson Halpern #151 series.
1. DIRECT DIGITAL CONTROLS

2. Water Differential Pressure:
   a. Dwyer #630 series.
   b. Rosemount #1 151-DP series.
   c. MAMAC.
   d. Provide dual piezoresistive sensing elements
   e. Provide isolation valves for sensor/transducer removal.
   f. Position, 0/100% open, for damper, inlet vane, or Similar:
   g. Potentiometer, 0/2000 OHM = 0/100%.
   h. Provide fused protection on output.

3. Humidity Sensors:
   a. Accuracy: +/- 2%.
   b. Range: 1% - 100%.
   c. Solid State
   d. Shall have digital display one (1) per floor in locations as identified by TMS.

4. Air Flow:
   a. Pitot array.
   b. Air Monitor, Ebtron or equal.
   c. Accuracy: +/- 2% of reading.
   d. Repeatability +/- 0.25% of reading.

5. Water Flow:
   a. Turbine type flow meter. Vortex shedding is not acceptable.
   b. Provide valved type installation so as to allow removal of meter from pressurized system.
   c. Provide frequency to voltage transducer.
   d. Provide electronic calculation of GPM.
   e. Accuracy: +/- 2% of reading.

6. Transducers:
   a. MAMAC or approved equal.
   b. 0 - 10 VDC output.

7. Control Valves – Two-Way: Control valves shall be Belimo or equal.
   a. Valves 1/2" through 2" shall be ball type valves bronze body, female NPT threads, and shall be rated at 250 psi maximum working pressure. Valve stems and balls shall be stainless steel or other approved, highly polished, corrosion resistant alloy shall be rated at a minimum of 400 PSI WOG. All valves shall have blowout proof stem design; glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 400 PSI rating. Stem packing gland screw shall be adjustable for wear. Two-way flow type shall be equal percentage and three-way flow type shall be linear. Composition discs shall be replaceable.
and provide tight shut off. Maximum close off pressure shall be 35 psid. Minimum resolution shall be 40:1.

b. Chilled Water: Valves 2-1/2" through 4" shall be globe valves cast iron, flanged type, and shall be rated at 125 psi maximum working pressure. Valve stems shall be stainless steel or other approved, highly polished, corrosion resistant alloy. Stem packing shall be spring loaded EP V-rings and stem left shall be 3/4" to 1-1/2". Two-way flow type shall be equal percentage. Composition discs shall be replaceable and provide tight shut off. Maximum close off pressure shall be 25 psid.

8. Provide operators for each automatic damper of sufficient capacity to operate the damper under all conditions, and to guarantee tight close-off against system pressure encountered. Operators shall be electric/electronic full-proportioning or two position type as required. The assembly to include all mounting and linkage hardware required. The actuator to stroke to the power fail position where required. The assembly to include a position feedback potentiometer where required. The assembly to include an end switch to provide contact operation where required.

9. Damper Actuators: Electric actuators shall be by Belimo.
   a. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp shall be of a “V” bolt design with associated “V” shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a “V” clamp assembly of sufficient size to be directly mounted as an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or setscrew type fasteners are not acceptable.
   b. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
   c. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe are not acceptable.
   d. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
   e. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting pulse width modulating control signal and full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal.
   f. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
   g. All proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
   h. Actuators shall be provided with conduit fitting and a minimum 3-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
   i. Actuators shall be UL 873 listed and CSA Class 4813 02 certified meeting correct safety requirements and recognized industry standards.
   j. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator’s rate torque and shall have a 2-year manufacturer’s warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.

10. Valve Actuators: Electric actuators shall be by Belimo.
a. Actuator shall be full modulating, floating, tristate, two-position, and/or spring return as indicated on points list. Specified fail-safe actuators shall require spring return.
b. Modulating valves shall be positive positioning, responding to a 2-10 VDC or 4-20mA signals. There shall be a visual valve position indicator.
c. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer.
d. Actuator shall provide minimum torque required for proper valve close off. The actuator shall be designed with a current limiting motor protection. A release button-clutch or handle on the actuator -shall be provided for manual override.

11. General Control Dampers:

a. Motorized dampers, unless otherwise specified elsewhere, shall have damper frames using 13 gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing. Damper blades shall not exceed ten (10) inches in width or 48" in length. Blades are to be suitable for high velocity performance. Damper bearings shall be as recommended by manufacturer for application. Bushings that turn in the bearing are to be oil impregnated sintered metal. All blade edges and top and bottom of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals may be spring-loaded stainless steel. The seals shall provide a maximum of 1% leakage at a wide open face velocity of 1500 FPM and 4" W.C. close-off pressure. The damper linkage shall provide a linear flow or equal percentage characteristic as required.

b. Control dampers shall be parallel or opposed blade type as scheduled on drawings. Outdoor and return air mixing box dampers shall be parallel blade, arranged to direct airstreams towards each other. All other dampers may be parallel or opposed blade type.

c. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 2000 fpm air velocity in the open position. In addition the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 250°F, 350°F, or 450°F depending upon the actuator. Appropriate electric actuators shall be installed by the damper manufacturer at time of damper fabrication. Factory supplied caulked sleeve shall be 20 gage for dampers through 84" wide. Damper and actuator assembly shall be factory cycled 10 times to assure operation. All wiring or piping material required to interconnect the actuator with detection and/or alarm or other systems shall be furnished by others as detailed elsewhere in the specification. Dampers all be Ruskin Model CD50 or approved equal.

12. Local Controls Panels:

a. All relays, switches transducers and other held interface devices, for equipment located within the mechanical equipment rooms, shall be panel mounted. Provide a convenience 120 VAC receptacle in each panel. All electrical devices within the panel shall be wired to a numbered terminal strip. All wiring within the panel shall be run in wiring tray in accordance with NEMA and UL standards, and shall meet all local codes. Panels shall be NEMA type suitable for applications as required. Provide a final as-built control drawing, reduced, laminated, and mounted inside of the panel door.

13. Miscellaneous:

a. The Controls Contractor shall furnish all electric relays and coordinate with the supplier of magnetic starters for the auxiliary contact requirements. All electrical control devices shall be of a type to meet current, voltage, and switching requirements of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.
14. Flow Meter:
   a. Flow meter shall be furnished by the controls contractor and coordinated with Division 15 contractor for location and installation. The mass flow meter shall be Sparling Tigermag EP mag meter or equal (no known equal) flow meter complete with NIST certification for maximum flow rate, refer to schedule on the drawings for flow rate requirements. Provide ANSI B-16.5 type mating flanges requiring no grounding rings. Provide Factory Mutual approved microprocessor based magnetic flow meter especially designed and calibrated to measure clean water flow rates from zero (0) to fifteen (15) FPS, ranging in temperature from 32º F to 250º F. Flow sensitivity shall be 0.01 FPS. Meter shall be provided with symmetrical concentric velocity increasing and reducing tapers as detailed and drawings as required by the manufacturer to properly stabilize and straighten the flow for measurement accuracy specified. Furnish wet flow versus output signal calibration in accordance with schedule fluid velocity and flow rates, certified by the manufacturer as in a flow lab with secondary standard of measure traceable to the National Institute of Standards Technology (NIST). Meter accuracy shall be 1% of absolute flow for any value set between 0 and 0.9% if full scale flow. Meter internal linear construction shall be of polyurethane and stainless steel. Meter electronics shall be contained in a waterproof enclosure, mounted directly on the meter element; electronics shall detect “empty pipe” and shall automatically force the output to zero. Front window of electronics assembly shall contain six (6) segment readout for total flow. It shall be possible to completely program the meter through the glass without opening the case, utilizing Hall Effect magnetic technology. Meter shall be equipped with an isolated 4-20 ma signal output, programmed in accordance with the flow ranges shown on the drawings. Meter shall also be equipped with an open collector pulsed output scaled to emit up to 20 pulses per second in response to programmed flow rates. Meter shall be supplied with 20 feet of interconnecting cable. Install with adequate length of straight unobstructed pipe upstream and downstream per manufacturers recommendation.

   b. Integrated, monitor and RTD temperature sensors will be wire wound 1000 platinum RTDs with a 0.385 alpha. They shall be either 3 or 4 wire type and be furnished as a matched pair. For chilled water service, they shall agree at ice point within 0.050. If the input circuit for the BTU DDC does not accept 3 or 4 wire sensors, then industrial grade digital transmitters match-calibrated to the sensors shall be furnished. Commercial grade analog transmitters are too prone to long-term drift and are not acceptable. Sensors shall have a stamped metal tag showing manufacturers part number and the resistance of the sensor at either ice or boiling point to allow routine calibration checks and identical replacement in the event of failure. A stainless steel thermowell shall be provided with an insertion length not less than 2.5" to avoid conduction errors from the pipe wall. If the piping will not accommodate this depth, install in an elbow. Sensor length shall be as required by the well depth, with a spring to force the probe tip to seat in the well. If transmitters are furnished, they shall have the smallest span, which will accommodate the range values expected. For chilled water, 4 mA shall occur at ice point to permit easy verification of calibration. RTDs shall be Rosemont, Telmar, Weed or equal.

15. TES Tank Instrumentation:
   a. Controls contractor shall provide minimum fifteen thermowells for TES Tank as indicated 15780-2.4-A.9. Controls contractor shall be fully responsible to coordinate installation of thermowells with mechanical contractor and TES system supplier.

   b. The thermal charge instrumentation shall be provided by the Controls Contractor.

   c. Level indication of automatic means shall be provided by the controls contractor. The automatic instrument shall be a level instrument sensing water depth by measuring the delay times associated with a series of electrical pulses, converting the pulses to a 4 to 20 ma signal for use in monitoring the volumetric conditions of the storage structure.
d. Any instrument nozzles, supports, mounting brackets or other welded tank attachments shall be provided as required. Instrument conduit and wiring shall be provide by the controls contractor.

### 2.11 ELECTRICAL BULK MATERIALS

**A.** The controls contractor shall be fully responsible to provide all wiring (low voltage, 120 volts, etc.) and conduit (3/4" minimum or as required by electrical codes) for connection of all associated DDC sensors, panels, valves, and any other DDC components for a completely operational DDC system.

**B.** Enclosures: Terminal boxes located indoors shall be rated for NEMA 1. Terminal boxes exposed to outdoors shall be rated for NEMA 12. Terminal boxes with potential water leakage shall be rated for NEMA 4X. They shall have protective coatings suitable to the environment in which they are to be installed. All enclosures shall be hinged with lockable doors.

**C.** Transformers: Provide step-down transformers where control equipment operates at lower than circuit voltage. Transformers serving shall be fed from the fan motor leads, or fed from the nearest distribution panelboard or motor control center, using circuits provided for the purpose. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Size transformers so that 80 percent of the rated capacity equals the connected load. Enclose transformers in a steel cabinet with conduit connections. Provide a disconnect switch on the primary side and a fuse cutout on the secondary side. Transformers shall conform to UL 506.

**D.** The Controls Contractor shall furnish all electrical relays and coordinate with the supplier of magnetic starters for the auxiliary contact requirements. All electrical control devices shall be of a type to meet current, voltage, and switching requirement of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.

**E.** Wiring:

1. Provide complete electric wiring for all temperature control apparatus, including wiring to transformer primaries, panels, valves, etc.
2. Control circuit conductors which run in same conduit as power circuit conductors shall have same insulation level as power circuit conductors.
3. Circuits operating at more than 100 volts shall be in accordance with Section 16050, "Basic Materials and Methods".
4. Circuits operating at 100 volts or less shall be defined as low voltage and shall be run in rigid or flexible conduit, metallic tubing, metal raceways or wireways, armored cable, or multiconductor cable. Use multiconductor cable for concealed accessible locations only. Provide circuit and wiring protection as required by NFPA 70. Aluminum-sheathed cable or aluminum conduit may be used but shall not be buried in concrete.
5. Provide all exposed wiring shall be in rigid conduit (minimum ¾") or EMT. Refer to Section 16050, "Basic Materials and Methods" for different usages of rigid conduit, EMT, or IMT. All wiring in return air plenums shall be plenum rated.
6. For less than nominal 120V service: Cable in control panels for analog loops shall be twisted and shielded two conductor, #16 x 30 stranded with #22 AWG drain wire and aluminum-polyester 100 percent shielding cover for each pair. Cable outside of control panels for analog signal loops shall be single twisted #18 AWG shielded pair. Conductors shall be copper coated with Class B strand. Insulation shall be 30 mils XPLE rated at 300 volts. Cable for digital signals shall be two conductor, #16 x 30 stranded. Each conductor shall be color coded. Each cable shall have polyethylene jacket.
7. Wire for low voltage DC and electronic circuits carrying less than 0.5 ampere, cable of two or more conductors, shall be not smaller than No. 18 AWG stranded copper (shielded).
8. Shield cables carrying analog signals and install in separate conduit from AC power circuits.
9. Terminate cables in solder or screw type terminal strips. Do not tap cables at intermediate points.
10. Color code or number wires, whether individual or in cables, for identification.
11. Cables terminating in screw type terminal strips shall have pressure type connectors conforming to UL 486A. Wire in physical contact with compression screw is not acceptable.

F. Power line Surge Protection: Power circuits for each controller shall be individually electrically isolated to protect against transients, spikes and power surges. Optical isolation shall be provided either as an integral component of the controller or provided as a separate interface device between the controller and field wiring. Fuses are not permitted.

G. Sensor and Control Wiring Surge Protection: Control and sensor circuits for each controller shall be individually electrically isolated to protect against transients, spikes, and power surges. Each local controller input system and output system shall individually optically isolated from other inputs and outputs on other local controllers’ field wiring. Optical isolation shall be provided either as an integral component of the controller or provided as a separate interface device between the controller and field wiring. Fuses are not permitted for surge protection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.2 PROTECTION

A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 GENERAL WORKMANSHIP

A. Install equipment, piping, wiring/conduit parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.4 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

3.5 WIRING

A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications.

B. Where Class 2 wires are in concealed and accessible locations, approved cables not in raceway may be used provided that:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
2. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.
3. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
4. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.

C. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

D. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.

E. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
F. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

G. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.

H. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

I. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

J. Adhere to Division 16 requirements for installation of raceway.

K. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

L. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.6 FIBER OPTIC CABLE SYSTEM

A. All cabling shall be installed in a neat and workmanlike manner. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

B. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post installation residual cable tension shall be within cable manufacturer's specifications.

C. Fiber optic cabinets, hardware, and cable entering the cabinet shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

3.7 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequate for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Install duct static pressure tap with tube end facing directly down-stream of air flow.

F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

H. Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.

3.8 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Install and adjust flow switch in accordance with manufacturers' instructions.

C. Assure correct flow direction and alignment.

D. Mount in horizontal piping - flow switch on top of the pipe.

3.9 ACTUATORS

A. Mount and link control damper actuators per manufacturer's instructions.

1. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.10 WARNING LABELS

A. Affix labels on each starter and equipment automatically controlled through the DDC System. Warning label shall indicate the following:

CAUTION

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Affix labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects. Labels shall indicate the following:

CAUTION

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.
3.11 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2” of termination with a cable identifier and other descriptive information.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1-cm (1/2”) letters on nameplates.

D. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.12 CONTROLLERS

A. Provide a separate Controller for each major piece of HVAC equipment. A custom application controller may control more than one system provided that all points associated with that system are assigned to the same controller. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.

3.13 PROGRAMMING

A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming

1. Provide programming for the system as written in the specifications and adhere to the sequence strategies provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into any custom-written control programs sufficient comment statements or inherent flow diagrams to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface

1. Standard Graphics. Provide graphics for each major piece of equipment and floor plan in the building. This includes each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These standard graphics shall show all points dynamically as specified in the points list. Furnish Graphics as listed below:
   a. (1) per each piece of mechanical equipment (Chiller, AHU, etc.)
   b. (1) per each mechanical system (chilled water, hot water etc.).
   c. (1) Main starting point graphic showing site layout with navigation buttons to all other graphics.
   d. (1) Floor Plan graphics per floor showing mechanical equipment.

2. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.
3. As part of this execution phase, the controls contractor will perform a complete test of the operator interface. Test duration shall be a minimum of [16] hours on-site. Tests shall be made in the presence of the University or University’s representative.

E. Demonstration: A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall dedicate a minimum of 16 hours on-site with the University and his representatives for a complete functional demonstration of all the system requirements. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation.

3.14 CLEANING

A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.15 TRAINING

A. Provide a minimum of [4] classroom training sessions, [4] hours each, throughout the contract period for personnel designated by the University. Computer-based audio-visual training may be substituted for up to [8] hours of hands on training.

B. Train the designated staff of University’s representative and University to enable them to proficiently operate the system; create, modify and delete programming; add, remove and modify physical points for the system, and perform routine diagnostic and troubleshooting procedures.

C. Additional training shall be available in courses designed to meet objectives as divided into three logical groupings; participants may attend one or more of these, depending on the level of knowledge required:

1. Day-to-day Operators
2. Advanced Operators
3. System Managers/Administrators

D. Provide course outline and materials as per Part 1 of this Section. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of the installed hardware or at the customer’s site.

G. This training shall be made available in addition to the interactive audio-visual tutorial, provided with the system.
3.16 ACCEPTANCE

A. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and University. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the University’s representative. Such tests shall then be performed as part of the warranty.
SECTION 15990 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 SCOPE

A. This section includes testing, adjustment, and balancing of air systems, hydronic systems, and measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

AABC National Standards For Total System Balance.
ADC Test Code For Grilles, Registers, And Diffusers.

B. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance.

C. Independent Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum five years documented experience certified by AABC.

D. Perform Work under supervision of AABC Certified Test and Balance Engineer experienced in performance of this Work and licensed in the State of California.

E. Sequencing:

1. Sequence work under the provisions of Section 01010.
2. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.3 SUBMITTALS

A. Refer to Section 15010 for additional requirements.

B. Submit the name of the testing adjusting and balancing agency for approval within 30 days after award of Contract.

C. Field Reports:

1. Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
2. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for inclusion in operating and maintenance manuals.
4. Provide reports in binder manuals complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating sensor locations.

5. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.

1.4 TEST AND BALANCE REPORTS

A. Provide testing, adjusting, and balancing reports that bear the seal and signature of the Test and Balance Engineer. The report shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the reference standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems.

B. Draft Report:

1. Upon completion of testing, adjusting, and balancing procedures, prepare draft report in a complete, factual, accurate, and legible manner on approved forms.
2. Organize and format draft reports in the same manner specified for the final reports.
3. Submit two complete sets of draft reports to the University Representative. One complete set will be returned.

C. Final Report:

1. Upon verification and approval of draft reports, prepare final reports, typewritten, organized, and formatted as specified below.
2. Submit six (6) complete sets of final reports.
3. Report forms shall be standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, 3-ring binders. Divide the contents of the binder into the divisions listed below, separated by divider tabs:
   a. General Information and Summary
   b. Air Systems
   c. Hydronic Systems
   d. Temperature Control Systems

D. Report Contents: Provide the following minimum information, forms, and data:

1. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, University, Engineer, Commissioning Agent and Project. Include addresses, contact names, and telephone numbers. Also include a certification sheet containing the name, address, and telephone numbers. Also include a certification sheet containing the name, address, and telephone number and signature of the Test and Balance Technician. Include in this division a listing of the instruments used for the procedures, along with proof of calibration.
2. The remainder of the report shall contain, as a minimum, the appropriate standard AABC report forms containing the information required for each respective item and system.
PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 AGENCIES

A. Associated Air Balance Council (AABC).

3.2 PRELIMINARY PROCEDURES

A. For water system balancing, perform the following:
   1. Open valves to full open position.
   2. Remove and clean all strainers.
   3. Examine hydronic systems and determine if water has been treated and cleaned.
   4. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow.

B. For air system balancing, perform the following:
   1. Obtain design drawings and specifications from the Contractor, and become thoroughly acquainted with the design intent.
   2. Obtain copies of shop drawings of all air-handling equipment, outlets, (supply, return, and exhaust) and temperature control diagrams, from the Contractor.
   3. Compare design to installed equipment and field installations.
   4. Walk the system from the system air-handling equipment to terminal units to determine variations of install from design.
   5. Check filters for cleanliness.
   6. Check volume dampers and combination fire smoke dampers for correct and locked position, and temperature control for completeness of installation before starting fans.
   7. Prepare test report sheets for both fans and distribution devices. Obtain manufacturer’s outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.
   8. Determine the best locations in main and branch ductwork for most accurate duct traverses.
   9. Provide outlet schematic diagrams of system “as-built” ductwork and piping layouts to facilitate reporting.
   10. Check lubrication at all motors and bearings.
   11. Systems are started and operating in a safe and normal condition.
   12. Temperature control systems are installed complete and operable.
   13. Proper thermal overload protection is in place for electrical equipment.

C. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

D. Beginning of work means acceptance of existing conditions.
3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the University Representative to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.4 INSTALLATION TOLERANCES

A. Hydronic Systems: Adjust to within plus or minus 5 percent of design.

B. Air Handling and Fan Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

C. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.5 ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards and closing doors to electrical switch boxes.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Engineer.

F. Check and adjust systems approximately six months after final acceptance and submit report.

3.6 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential and pressure differential.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.7 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

3.8 DUCT PRESSURE / LEAKAGE TESTING

A. Mechanical contractor shall conduct leakage test on the entire ductwork system. Mechanical contractor shall coordinate with Test and Balance Agency, the University and Engineer for witness and certification of all tests. Tests shall be performed prior to installing ductwork insulation. Mechanical contractor shall submit test reports to the Test and Balance Contractor for review prior to final review by the University representative.

3.9 SCHEDULES

A. Report Forms: Agency shall compile the following data as outlined below:

1. Title Page
   a. Name of Testing, Adjusting, and Balancing Agency
   b. Address of Testing, Adjusting, and Balancing Agency
   c. Telephone number of Testing, Adjusting, and Balancing Agency
   d. Project name
   e. Project location
   f. Project Engineer
   g. Project Engineer
   h. Project Contractor
i. Project altitude
j. Report date

2. Summary Comments
   a. Design versus final performance
   b. Notable characteristics of system
   c. Description of systems operation sequence
   d. Nomenclature used throughout report
   e. Test conditions

3. Instrument List
   a. Instrument
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Range
   f. Calibration date

4. Electric Motors
   a. Manufacturer
   b. Model/Frame
   c. HP/BHP
   d. Phase, voltage, amperage; nameplate, actual, no load
   e. RPM
   f. Service factor
   g. Starter size, rating, heater elements
   h. Sheave Make/Size/Bore

5. V-Belt Drive
   a. Identification/location
   b. Required driven RPM
   c. Driven sheave, diameter and RPM
   d. Belt, size and quantity
   e. Motor sheave diameter and RPM
   f. Center to center distance, maximum, minimum, and actual

6. Pump Data
   a. Identification/number
   b. Manufacturer
   c. Size/model
   d. Impeller
   e. Service
   f. Design flow rate, pressure drop, BHP
   g. Actual flow rate, pressure drop, BHP
   h. Discharge pressure
   i. Suction pressure
   j. Total operating head pressure
   k. Shut off, discharge and suction pressures
   l. Shut off, total head pressure
7. Chillers
   a. Identification/number
   b. Manufacturer
   c. Capacity
   d. Model number
   e. Serial number
   f. Evaporator entering water temperature, design and actual
   g. Evaporator leaving water temperature, design and actual
   h. Evaporator pressure drop, design and actual
   i. Evaporator water flow rate, design and actual
   j. Condenser entering water temperature, design and actual
   k. Condenser pressure drop, design and actual
   l. Condenser water flow rate, design and actual

8. Cooling Tower
   a. Tower identification/number
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Rated capacity
   f. Entering air WB temperature, specified and actual
   g. Leaving air WB temperature, specified and actual
   h. Ambient air DB temperature
   i. Condenser water entering temperature
   j. Condenser water leaving temperature
   k. Condenser water flow rate
   l. Fan RPM

9. Coil Data
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Entering air dB temperature, design and actual
   g. Entering air WB temperature, design and actual
   h. Leaving air dB temperature, design and actual
   i. Leaving air WB temperature, design and actual
   j. Air pressure drop, design and actual

10. Air Moving Equipment
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Arrangement/Class/Discharge
    f. Air flow, specified and actual
    g. Return air flow, specified and actual
    h. Outside air flow, specified and actual
    i. Total static pressure (total external), specified and actual
j. Inlet pressure
k. Discharge pressure
l. Sheave Make/Size/Bore
m. Number of Belts/Make/Size
n. Fan RPM

11. Return Air/Outside Air Data
   a. Identification/location
   b. Design air flow
   c. Actual air flow
   d. Design return air flow
   e. Actual return air flow
   f. Design outside air flow
   g. Actual outside air flow
   h. Return air temperature
   i. Outside air temperature
   j. Required mixed air temperature
   k. Actual mixed air temperature
   l. Design outside/return air ratio
   m. Actual outside/return air ratio

12. Exhaust Fan Data
   a. Location
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Air flow, specified and actual
   f. Total static pressure (total external), specified and actual
   g. Inlet pressure
   h. Discharge pressure
   i. Sheave Make/Size/Bore
   j. Number of Belts/Make/Size
   k. Fan RPM

13. Duct Traverse
   a. System zone/branch
   b. Duct size
   c. Area
   d. Design velocity
   e. Design air flow
   f. Test velocity
   g. Test air flow
   h. Duct static pressure
   i. Air temperature
   j. Air correction factor

14. Air Distribution Test Sheet
   a. Air terminal number
   b. Room number/location
   c. Terminal type and size
d. Design velocity  
e. Design air flow  
f. Test (final) velocity  
g. Test (final) air flow  
h. Percent of design air flow

B. Equipment Requiring Testing, Adjusting and Balancing:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Air Balance</th>
<th>Water Balance</th>
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</thead>
<tbody>
<tr>
<td>HVAC Pumps</td>
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<tr>
<td>Centrifugal Water Chillers</td>
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<td>X</td>
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<tr>
<td>Cooling Towers</td>
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<tr>
<td>Air Coils</td>
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<td>Exhaust Fans</td>
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<tr>
<td>Air Inlets and Outlets</td>
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</tbody>
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END OF SECTION 15990
PART 1 - GENERAL

1.1 GENERAL

A. All of the work required to be provided as described in this Division 16, Section 16010 of the specifications shall be provided by a single entity sub-contractor skilled in this specialty, holding a valid C-10 California contractor's license, and such sub-contractor shall be designated and listed in the sub-contractor listing portion of the bid form by the prime contractor when bidding this work to the University.

1.2 GENERAL REQUIREMENTS

A. The following requirements shall apply to Division 16 sections.

B. Prohibited Materials and Construction Practices:

1. Plastic conduit for interior electrical use.
2. Aluminum conduit: Consult University for locations where use of aluminum conduit will be permitted.
3. Aluminum conductors, cables, and busbars.
4. Use of incompatible materials: Aluminum fittings and boxes shall not be used with steel conduit. All materials in a raceway system shall be compatible.
5. Use of set screw type conduit fittings.
6. Use of wire to support conduit, boxes.
7. Use of wood strips and wood screws to support lighting fixtures.
8. Use of Class J fuses.
10. Underground ducts and conduits crossing above gas piping. These shall cross gas lines below the gas piping without exception.
11. Reconditioned or used devices e.g. switches, circuit breakers.
12. Radioactive and self illuminated exit signs.

C. Guarding:

1. Provide protection for moving parts and hazardous conditions.
2. Provide industrial accident and warning signs per ANSI and OSHA standards.
3. Erect and maintain suitable barriers, protective devices, temporary lights and warning signs for the protection of the public and employees.
4. Conform with applicable safety regulations, including those of the University's.

D. Permits: Permit will be required from local air quality management district to install and operate generators. The Contractor shall submit the application, pay all the required fees for the permit and coordinate with University and local air quality management district staff regarding testing. The University will assist the Contractor in completing the application. Installation work shall not be started without local air quality management district authorization to construct. The generator set shall not be operated without local air quality management district permit. Contractor shall be responsible for submission of application and fees required for installation of generators.

E. Temporary Electrical Service:
ART CENTER AND SATELLITE COOLING PLANT
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD
BAKERSFIELD, CA

ELECTRICAL GENERAL REQUIREMENTS

1. All temporary connections shall be approved by the University. Submit drawings to University's Representative for approval.
2. The Contractor shall provide labor and materials required for the installation and maintenance of temporary lighting and required power sources for the Contractor's equipment inside the building or construction site and for pedestrian walkways during the period of construction.
3. The building or construction site shall be sufficiently illuminated so that construction work can be safely performed. Special attention shall be given to adequately lighting stairs, ladders, pedestrian walkways, floor openings, etc. Walkway lights shall be controlled by a switch within the building or construction site.

F. Seismic Anchoring:

1. All switchgear and other free standing electrical equipment shall be anchored to withstand seismic forces for seismic zone IV, and meets requirements of California CCR, Title 24. Submit documentation of manufacturer’s done on similar equipment which demonstrates compliance.
2. Cable tray shall be installed complete with all seismic anchoring and bracing.
3. Conduit supports shall be adequately sized and braced to comply with seismic criteria.

G. Cleaning: Vacuum clean the interiors of all switchboards, substations, panelboards, transformers, motor control centers and transfer switches upon completion of all work to remove dust and debris. After cleaning, cover all equipment to prevent any construction dust from recurring. Before equipment is energized, vacuum all interiors a second time to assure clean equipment.

H. Painting:

1. Touch up damaged or scratched paint on electrical equipment to match the manufacturer's original finish.

1.3 STANDARDS

A. Standards: Comply with latest editions of applicable regulations and standards of:

1. Insulated Cable Engineers Association (ICEA).
2. Institute of Electrical and Electronics Engineers (IEEE).
6. Certified Ballast Manufacturers (CBM).
8. Underwriter's Laboratories (UL).
10. General Order 95 and 128.

B. Proof of such compliance shall be submitted to the University's Representative for approval.

1.4 QUALITY ASSURANCE

A. All materials and equipment shall be of new and recent manufacture and supplied by manufacturer's authorized distributors. Reconditioned equipment shall not be permitted.
B. All materials and equipment shall bear the inspection label of the underwriter's laboratories (UL) where applicable. Materials and equipment shall be the latest standard product and shall be of the grade indicated by the trade names given.

C. If a material and equipment with UL listing is not available from any manufacturer, Contractor shall furnish materials and equipment tested and listed by a reputable independent testing organization acceptable to the University.

1.5 SUBMITTALS

A. General: Submittals shall be furnished by Contractor for each device, equipment, building wiring, medium voltage cable, light fixture controls, splicing and testing intended to be used on the project and as indicated in other sections. Submit material list and obtain review, prior to submission of manufacturer's data and shop drawings.

B. Submittals: Piecemeal submittals will not be acceptable. Submit in brochure form with all listings referenced to applicable sections and paragraphs in the specifications. Listing items 'as specified' without both name of manufacturer and model number or type (designation) is not acceptable.

C. Material List: Contractor shall submit a complete list of approved materials and equipment proposed for the project including that which is exactly as specified. List to contain only manufacturer's name and reference to applicable sections and paragraphs of the specifications. List shall be submitted minimum 2 weeks prior to submission of required submittals.

D. Any material or equipment installed without written approval shall be subject to immediate removal.

E. Equipment Layout Drawings: 1/4" = 1'-0" scale "equipment layout drawings" shall be provided for each equipment furnished under Division 16. Drawings shall show projected outline of each equipment proposed to be used including all working clearances and clearances for removal of equipment. Indicate any conflicts with other work. Submit drawings along with shop drawings for electrical equipment. Available spaces for equipment layout as shown on drawings are restricted. Contractor shall make sure that the equipment furnished, shall fit in the available space.

F. Furnish a certificate from switchgear manufacturer confirming that the main components and devices proposed to be used on the project shall be available for replacement for a minimum period of five (5) years from the date of final acceptance of the project by the University.

G. Furnish a list of materials within 30 days on notice to proceed indicating name of manufacturer and name of major equipment.

1.6 DELIVERY AND STORAGE

A. All material and equipment including conduit shall be stored to provide protection from weather and accidental damage. Follow manufacturer's written instructions when available.

B. Plastic conduit shall be stored on even supports and in locations not subject to direct sunrays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. High voltage cables shall be stored in accordance with manufacturer's recommendations.
1.7 PROGRESS OF UNDERGROUND CONSTRUCTION

A. The work shall proceed in a systematic manner so that a minimum of inconvenience to facility operations and traffic flow will result during the course of construction. Work crews shall confine operations to as small a length of work area per crew as practical. Entire closing of streets and intersections shall not be permitted. All parking lots and fire lanes shall be accessible at all times. As part of the construction schedule to be submitted, the Contractor shall submit a schedule that includes when and where work will occur in each street and street segment. Traffic control shall be provided to maintain proper and safe flow of pedestrian and vehicular traffic whenever work is done on streets, in parking lots etc.

B. A minimum of two (2) underground construction crews shall be used at all times.

C. Existing manholes and new cable trenches shall be ventilated to keep out harmful gases and dust during work and inspection. As part of the bid, the Contractor shall provide gasoline driven blowers for ventilation of manholes and trenches during work and inspections.

1.8 ELECTRICAL PHASING AND PHASE ROTATION

A. The Contractor shall maintain the present phasing and phase rotation at the facility. All new feeders being installed shall be checked and tagged for the proper phasing and phase rotation before connections to existing feeders and facilities.

B. After phasing and rotation checks, existing and new cables shall be tagged with the proper phase nomenclature.

C. The Contractor shall certify that circuits have been properly phased prior to paralleling.

1.9 ELECTRICAL SERVICE OUTAGES

A. To allow the University to coordinate the scheduling of classes and manpower for transferring of loads, the Contractor shall provide, through the University's Representative, a list of all outages required during the construction period.

1. The listing shall include, but not be limited to, the following:
   a. Facility to be de-energized.
   b. Time and duration of outage.
   c. Date requested.
   d. Alternate dates.

2. Because of class schedules and other critical operations at the campus, the timing of outages will be entirely at the direction of the University's Representative.

1.10 SEQUENCING OF ELECTRICAL WORK

A. Outages for interruption of electrical services, see paragraph 1.8.

B. Switching: All electrical loads shall be switched by University’s authorized personnel upon receipt of notice.
C. Coordination: The Contractor shall coordinate connections, circuit transfers, switching of loads, etc. with the University's Representative.

D. 12KV Installations: Upon receipt of all materials required for the completion of the project (15KV cable, splice, elbows, connectors, switch equipment pad/utility box, etc.) and the installation of certain portions of the work, the Contractor shall notify the University's Representative of their intent to proceed with the installations and connections. At that time the University's Representative shall inspect the Contractor's materials and installation to determine the completeness of preparations by the Contractor.

E. Prior to energizing of new and existing electrical equipment, the following "check-list" procedures shall be followed:

1. Correct phasing, phase rotation has been verified of all intended equipment, cable connections, and loads to be transferred. Tag existing and new conductors with phase identification markers.
2. Complete all splicing and termination of high voltage cable. Provide enough cable slack to form a 360 degree loop around the wall of each manhole, handhole, and cable vault (for cable transpose if phasing is wrong).
3. Hi-pot test voltage cables by an independent testing agency. (Obtain approval of Hi-pot tests.)
4. Thoroughly clean equipment enclosure interior. (Wipe down insulators, bus work, bushings, etc.) Remove any debris and check that all shipping blocks and strapping have been removed.
5. Check that the key systems are operable. (The University's Representative shall supply keys for existing equipment.)
6. Check operation of all switches.
7. Assure that all parts (panels, fuses, jumpers, barriers, etc.) are in place.
8. Check that the equipment ground bus is bonded to the grounding electrode system.
9. Electrical equipment shall be securely anchored in place.

F. Prior to starting work on the project, the contractor shall determine phase rotation at each location of work including connection point of temporary generators. Each individual cable shall be tagged, i.e., A Phase, B Phase, C Phase. The sequence of new or temporary work shall be identical to existing conditions.

1.11 POSTED OPERATING INSTRUCTIONS

A. Operating instructions shall be provided by the Contractor at the conclusion of the project for each system and each principal piece of equipment for the use of operating and maintenance personnel. The operating instructions shall include wiring and control diagrams showing the entire system, including, but not limited to, equipment, devices, and control sequences. All operating instructions shall be approved by the University's Representative.

B. Operating instructions shall be typewritten or engraved and shall be framed under glass or in approved laminated plastic and posted adjacent to each principal piece of equipment and shall include such instructions as start up, proper adjustment, operation, lubrication, shutdown, safety-precautions, procedure in the event of equipment failure, and any other necessary items of instructions as recommended by the manufacturer of unit.

C. Operating instructions exposed to the weather shall be made of weather-resisting materials or shall be suitably enclosed to be weather protected. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.
1.12 TRAINING

A. University staff and maintenance personnel shall be thoroughly trained (minimum four [4] hours) in the use of each system or major piece of equipment installed unless otherwise stated in other sections of Division 16. This training shall be provided as part of the Contractor's base bid to supply the system or equipment.

1.13 EQUIPMENT ANCHORING

A. All equipment bases shall be fabricated with an adequate number of anchor bolt holes designed to put the base in direct contact shear and tension with the concrete pad at all anchor bolt locations. Anchorage shall be designed to utilize simple ASTM A307 anchor bolts with heads imbedded 4 inches in concrete with an ultimate compressive strength of 3000 psi.

B. The mounting and attachment of the equipment to floor, pad or wall shall be designed for Seismic Zone 4 conditions. The contractor shall provide plans, anchor details and calculations, signed and stamped by a California registered structural engineer. This documentation shall be specific for the installation and submitted for review with the equipment shop drawings.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION 16010
SECTION 16030 – ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SCOPE:

A. Acceptance field testing and power system study requirements for electrical power systems.

1.2 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute, Inc. (ANSI) Publication:
   2. C37.010-79 (incl supplements) Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
   3. C37.16-88 Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements and Application Recommendations

B. International Electrical Testing Association Inc. (NETA) Publication:

C. Institute of Electrical and Electronic Engineers (IEEE) Publications:
   1. 141-93 Recommended Practice for Electric Power Distribution for Industrial Plants
   2. 242-86 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
   3. 399-90 Recommended Practice for Industrial and Commercial Power System Analysis
   4. 446-95 Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

D. National Fire Protection Association (NFPA) Publication:
   1. 70-99 National Electrical Code (NEC)

E. State of California Code of Regulations:

1.3 SUBMITTALS

A. Submit six (6) copies under provisions of Sections 01300.

B. Qualifications: Provide for:
   1. Independent testing organization.
   2. Designated project safety representative.
ART CENTER AND SATELLITE COOLING PLANT
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD
BAKERSFIELD, CA

3. NETA Certified Lead Engineer to be assigned to the project.
4. Power systems analysis firm.

C. Acceptance Test Procedures: Provide for:

1. Metalclad switchgear including circuit breakers
2. Meters and associated instrument transformers
3. Load interrupter switches
4. Transformers (all types)
5. Digital Meters
6. Ground fault protective systems
7. Low voltage circuit breakers (>400A)
8. Grounding system
9. Hi – Pot testing of medium voltage cables
10. Meggar testing of 600V feeder conductors

D. Short Circuit and Protective Device Coordination Study: Provide (6) copies in hard cover 3-ring binders, each including complete short circuit and protective device coordination studies. The study shall be submitted along with switchgear submittal. The Owner will not accept the switchgear submittal without the study.

E. Certified Test Reports: The final report for each test shall be signed and shall include the following information: Summary of the project, name of technicians performing the test, date and time of testing, weather conditions, name of Owner’s Representative witnessing the test, description of the equipment or cables tested, visual inspection report, description of the tests, test results, conclusions and recommendations, appendix including appropriate test forms, and identification of the test equipment used. Provide bound copies and submit within three (3) weeks of test completion for:

1. Metalclad switchgear including circuit breakers
2. Protective relays and associated instrument transformers
3. Meters and associated instrument transformers
4. Load interrupter switches
5. Transformers (all types)
6. Digital Meters
7. Ground fault protective systems
8. Low voltage circuit breakers (>400A)
9. Grounding system
10. Hi – Pot testing of medium voltage cables
11. Meggar testing of 600V feeder conductors

1.4 POWER SYSTEMS STUDY AND DEVICE PROGRAMMING

A. Provide short circuit and protective device coordination studies carried out by a professional electrical engineer registered in the State of California. Provide studies prepared by persons experienced in the work. Submit qualifications of individual(s) who will perform the work for approval prior to commencement of the studies. Provide studies in conjunction with equipment submittals to verify equipment ratings required. Submit a draft of the study to Owner’s Representative for the review prior to delivery of the study to the Owner. Make all additions or changes as required by the reviewer at no extra cost to the Owner.

B. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, tabulations of calculation quantities and results, conclusions, and recommendations.
Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant locations throughout the system. Study shall start at the Utility source of campus 5KV power and extend to the equipment furnished under this project including multifunction relays. All multifunction relays shall have settings developed and be programmed to meet the configuration of the electrical distribution system.

C. Short circuit and protective device studies must be prepared with a digital computer. Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on Drawing one-lines.

D. Utilize equipment load data for the study obtained by the Contractor from Contract Documents, including Contract Addendums issued prior to bid opening. Coordination study shall indicate proper coordination of protective devices furnished under the project with the upstream relays at the existing 5KV system. Verify existing setting of relays in field prior to start of work.

E. Submit an electronic file on CD ROM of the approved study for the Owner’s record.

1.5 QUALIFICATIONS

A. The contractor shall engage the services of an independent testing organization fully certified by NETA and a full member to provide final inspection, testing, calibration, and adjusting on the electrical distribution system as defined in this Section. The independent testing organization shall have been engaged in full practice for a minimum of five years. The organization shall be independent of the supplier, producer, or installer of the equipment, and located within sixty (60) miles radius of the project location. The organization shall be able to provide service and test equipment within four (4) hours.

1. The independent testing organization shall have a calibration program with accuracy traceable every six months, and in an unbroken chain, to the National Institute of Standards and Technology (N.I.S.T.).
2. The independent testing organization shall have a designated safety representative on the project. The safety standards shall include OSHA and NFPA 70E.
3. Testing, inspection and calibration shall be performed by an Engineering Technician, certified by NETA, with a minimum 5 years experience inspecting, testing and calibrating electrical distribution equipment, systems and devices. Information on the qualifications of the Certified Engineering Technician shall be submitted to the Owner’s Representative for approval minimum 45 days prior to the start of testing.
4. The qualifications of the independent testing organization shall be submitted to the Owner’s Representative for approval within 30 days of notice to proceed.

B. The power system study and device programming shall be performed by an independent, third party firm not involved in supply of the equipment.

1. The firm should be currently involved in high and low voltage power system evaluation. the study shall be performed, stamped and signed by a registered professional engineer in the State of California. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the Owner’s Representative for approval prior to start of the work. A minimum of 10 years experience in power system analysis is required for the individual in charge of the project.
2. The firm performing the study must be able to document capability and experience to provide assistance during start up. The individual in charge of the study work should have a proven field
experience. The individual in charge should be aware of most recent ANSI/IEEE changes and familiar with standards C37.010, C37.16, IEEE-141, IEEE-242, IEEE-399 and IEEE-446.

3. Study shall be performed using SKM Systems 'Dapper' Version 3.5 and 'Captor' Version 3.5 programs to match existing studies. In addition to the software generated printouts, produce a short circuit device evaluation table including the bus number, bus name, phase and ground fault currents, X/R ratio, 110% of the calculated fault current, bus bracing, and A/C rating of the devices on the bus.

4. Revise the study to include review comments at no additional cost to the Owner.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 All inspections shall be performed in accordance with applicable codes and standards including NEC, ANSI, IEEE, NEMA and OSHA.

A. The independent testing organization shall provide all materials, equipment, labor and technical supervision to perform the inspections and tests.

3.2 IMPLEMENTATION OF POWER STUDY RESULTS AND DEVICE PROGRAMMING

A. The drawings and specifications indicate the general requirements for the electrical equipment being provided. Changes and additions to equipment characteristics and ratings may be suggested by the results of the short circuit and protective device coordination studies. Submit any such proposed changes and additions as a part of the study material. Necessary field settings of devices, and adjustments and minor modifications to equipment to accomplish conformance with the accepted short circuit and protective device coordination studies shall be carried out by the particular manufacturer or by the Contractor at no additional cost to the owner.

3.3 EVALUATION / TEST PROCEDURES:

A. The contractor shall supply to the independent testing organization complete sets of approved shop drawings, coordination study, settings of all adjustable devices, and other information necessary for an accurate inspection and evaluation of the system prior to the performance of any tests.

B. After the evaluation of the system and equipment has been made, the independent testing organization shall submit for approval an acceptance test procedure for each item of electrical distribution equipment to be tested. Test procedures shall include the proposed system function test. No testing shall be performed until the test procedures have been reviewed and approved.

3.4 INSPECTION

A. A visual inspection of the installed equipment shall be performed by the independent testing organization to verify that the distribution equipment installed and to be tested is the equipment denoted on the approved shop drawings. The inspection shall check the equipment designations, device characteristics, special installation requirements, applicable codes and standards.
B. After completion of the visual inspection, a report shall be developed stating any discrepancies that may have been found.

3.5 TESTING, CALIBRATION AND ADJUSTMENT

A. The independent testing organization shall perform tests on each item of distribution equipment identified in accordance with the latest edition of the International Electrical Testing Association's (NETA) Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.

B. Submit description of tests based on NETA specifications for approval prior to testing.

C. Field acceptance testing shall be accomplished on each item of electrical distribution equipment installed or connected as part of this contract. This shall include:

   1. Metalclad switchgear including circuit breakers
   2. Meters and associated instrument transformers
   3. Load interrupter switches
   4. Transformers (all types)
   5. Digital Meters
   6. Ground fault protective systems
   7. Low voltage circuit breakers (>400A)
   8. Grounding system
   9. Description of tests for each equipment, cable, conductor
   10. Hi – Pot testing of medium voltage cables
   11. Meggar testing of 600V feeder conductors

D. Systems shall be energized or otherwise placed in service only after completion of all required tests and an evaluation of the test results has been completed.

3.6 SYSTEM FUNCTION TESTS

A. Each system provided under this Contract and covered by this Section shall be function tested to ensure total system operation. All tests shall be witnessed by Owner’s Representative. Provide minimum (14) days written notice to the Owner’s Representative prior to scheduling each test.

B. Upon satisfactory completion of equipment acceptance tests, the system functional tests shall be performed. It is the intent of system functional tests to prove the proper interaction of all sensing, processing, and action devices to effect the designed end product or result.

C. All interlocks, safety devices, fail-safe functions, and design functions shall be tested.

3.7 CORRECTION OF DEFICIENCIES: Any deficiencies found shall be rectified, and work affected by such deficiencies shall be completely re-tested at the contractor's expense. Final acceptance of the electrical power system is contingent upon satisfactory completion of the acceptance and system function tests.

END OF SECTION 16030
SECTION 16050 – BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies conduit, fittings and conduit bodies, 600 volt wires, boxes, panelboards, safety switches and cabinets and enclosures.

1.2 RELATED SECTIONS

A. Section 16010 - Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

B. Section 16030 - Electrical Acceptance Testing

C. Section 16170 - Grounding and Bonding

D. Section 16195 - Electrical Identification

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute, Inc. (ANSI) Publications:

1. C80.1-95 Rigid Steel Conduit, Zinc Coated
2. C80.3-95 Electrical Metallic Tubing, Zinc Coated
3. C80.5-90 Specification for Rigid Aluminum Conduit
4. FB 1-97 Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
5. OS 1-84 Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
6. OS 2-84 Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

B. National Electrical Manufacturers Association (NEMA) Publications:

1. AB 1-93 Molded Case Circuit Breakers
2. ICS 2-93 Industrial Control Devices, Controllers, and Assemblies
3. ICS6-93 Enclosures for Industrial Controls and Systems
4. KS 1-96 Enclosed Switches
5. PB 1 Panelboards
6. PB 1.1 Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
7. TC 2-90 Electrical Plastic Tubing and Conduit
8. WD 1-83 General Purpose Wiring Devices
9. WD 6-88 Wiring Device Configurations

C. National Fire Protection Association (NFPA) Publication:

1. 70-99 National Electrical Code (NEC)
D. State of California Code of Regulations:

1. Title 24, Part 3, CCR, 2001 California Electrical Code

E. Underwriters Laboratories, Inc. (U.L.) Publications:

1. 1-93 Standard for Flexible Metal Conduit
2. 6-93 Rigid Metallic Conduit
3. 50-95 Cabinet and Boxes
4. 67-79 (R86) Panelboards
5. 83-91 Thermoplastic Insulated Wires
6. 198E-88 Class R Fuses
7. 360-96 Liquid-tight Flexible Steel Conduit
8. 486A-91 Wire Connectors and Soldering Lugs, for use with Copper Conductors
9. 498-96 Attachment Plugs and Receptacles
10. 508-93 Industrial Control Equipment
11. 510-94 Insulating Tape
12. 514A-91 Metallic Outlet Boxes
13. 514B-89 Fittings for Conduit and Outlet Box
14. 651-95 Schedule for 40 & 80 Rigid PVC Conduit
15. 797-93 Electrical Metallic Tubing
16. 869A-93 Standard for Service Equipment
17. 1242-96 Standard for Intermediate Metal Conduit

1.4 SUBMITTALS

A. Submit under provisions of Sections 01300.

B. Product Data: Provide for:

1. Conduit and Connectors (all types)
2. Conductors (all types)
3. Cabinets, Enclosures and Junction Boxes
4. Safety Switches
5. Panelboards: Indicate outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker arrangement and sizes.
6. Surface Mount Raceways

C. Test Reports: Provide for:

1. Insulation resistance tests of low voltage conductors.
2. Operational tests.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01300.

B. Accurately record actual routing of all conduits.

C. Accurately record actual locations and mounting heights of outlet, pull and junction boxes.

D. Accurately record actual location of each new receptacle.
1.6 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70 and with all state adopted amendments, except where requirements herein are more stringent.

B. Furnish products listed and classified by Underwriters Laboratories, Inc. or a testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle Products to site.

B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

1.8 PROJECT CONDITIONS

A. The drawings are diagrammatic and shall not be scaled for exact locations: Field conditions and non-interference with other utilities and trades, shall determine exact locations.

B. Verify routing and termination locations of conduit prior to rough-in.

C. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

1.9 PROJECT/SITE CONDITIONS

A. The arrangement of and connection to equipment shown on the drawings is based upon information available to the Engineer at the time of design and is not intended to show exact dimensions peculiar to a specific manufacturer. The drawings are, in part, diagrammatic and some features of the illustrated equipment installations may require revision to meet actual equipment requirements.

B. Install Work in locations shown on approved Drawings, unless prevented by Project conditions.

1.10 COOPERATION WITH WORK UNDER OTHER DIVISIONS

A. Cooperate with other trades to facilitate general progress of Work. Allow all other trades every reasonable opportunity for installation of their work.

B. Make such progress in the Work to not delay work of other trades.

1.11 DISCREPANCIES

A. The Contractor shall check all drawings furnished to him immediately upon their receipt and shall promptly notify the Engineer of any discrepancies. Figures marked on Drawings shall in general be followed in preference to scale measurements. Large-scale drawings shall in general govern small-scale drawings. The Contractor shall compare all drawings and verify the figures before laying out the work and will be responsible for any errors, which might have been avoided thereby.
1.12 CHANGES: The contractor shall be responsible to make and obtain approval from the engineer for all necessary adjustments in piping layouts as required to accommodate the relocation of equipment and/or devices which are affected by any approved authorized changes or product substitutions. All changes shall be clearly indicated on the "record" drawings.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated. Except where specifically indicated otherwise, provide only new materials having all legally required approvals and/or labels. Items of a similar nature shall be of the same type and manufacturer.

2.2 CONDUIT

A. Rigid Steel Conduit (Zinc-coated): ANSI C80.1, UL 6, hot-dip galvanized, threaded type.
B. Electrical Metallic Tubing: UL 797, ANSI C80.3.
C. Rigid Plastic Conduit: NEMA TC-2, UL 651, PVC Schedule 40, Carlon or equal.
D. Liquidtight Flexible Non-Metallic Conduit: UL 1660, Non-metallic, liquid-tight conduit with a polyvinyl chloride reinforced core. Conduit must conform to NEC 351B. Electri-Flex Liquatite® Type LNM-P, Kellems Polytuff I or equal.
E. Flexible Metal Conduit: UL 1.

2.3 FITTINGS

A. Fittings for Rigid Metallic Conduit: UL 514B, threaded-type.
B. Fittings for EMT: Compression type. Split or set-screw couplings unacceptable.
D. Fittings for Flexible Metal Conduit: ANSI/NEMA FB 1.
E. Expansion/Deflection Fittings: Provide fitting capable of a straight line expansion movement of 2" in either direction and a movement of 3/4" from the normal in all other directions, OZ Gedney Type AXDX, or Equal (no known Equal). Provide complete with grounding and bonding jumpers.

2.4 CONDUCTORS: Conductors shall bear the date of manufacture imprinted on the insulation with other identification. Wire and cable manufactured more than 6 months before delivery to the job site shall not be used.

A. 600 Volt Wires and Cables: UL 83. Conductors # 10 AWG and below shall be solid conductors and # 8 AWG and larger shall be stranded copper unless otherwise noted. Insulation shall be type THHN/THWN
unless otherwise noted. Conductors shall be stranded from exterior lighting underground handholes to the pole mounted fixture.

B. Color Coding: Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutral shall be white with colored (not green) stripe. Color of ungrounded conductors in different voltage systems shall be as follows:

1. 208Y/120 volt, 3Ø:
   a. Phase A - black
   b. Phase B - red
   c. Phase C - blue.

2. 480Y/277 volt, 3Ø:
   a. Phase A - brown
   b. Phase B - orange
   c. Phase C - yellow.

C. Minimum size for branch circuits shall be No. 12 AWG, unless otherwise noted.

2.5 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1, galvanized steel.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported, include 1/2 inch male fixture studs where required.
   2. Concrete Ceiling Boxes: Concrete type.

B. Outlet Boxes: ANSI/NEMA OS 2.

C. Cast Boxes: NEMA FB 1, Type FD, cast ferroalloy. Provide gasketed cover and threaded hubs by box manufacturer.

2.6 CABINETS: UL 50.

A. Cabinets for same type of use shall be the product of a single manufacturer.

B. Construct of cold-rolled drawing quality steel, with metal gages and construction methods conforming to National Electrical Code requirements, and Underwriters Laboratories' standards. Provide 12 gauge G-90 grade galvanized steel minimum, unless otherwise noted.

C. Finish doors, trims, and back boxes for surface-mounted cabinets in finished areas by applying a rust-resistant treatment, prime coat, and a final coat of manufacturers standard enamel or lacquer finish. Galvanize all other sheet metal components of cabinets including back boxes for flush cabinets, excepting non-ferrous metal parts, or steel parts provided with cadmium plating or equivalent protective plating.

D. Equip doors with concealed or semi-concealed hinges and with flush or semi-flush spring catch type flush cylinder locks. Key cabinet doors of similar use alike, and provide two keys with each lock.
E. Equip cabinets for use with telephone, alarm or signal systems with a 0.5" thick plywood backboard. Equip cabinets with terminal strips where so specified. Equip cabinets with nameplates.

F. Surface cabinets shall be furnished without knockouts. Punch or drill required openings during installation. Equip flush back boxes with manufacturer's standard pattern of knockouts.

G. Equip cabinet doors exceeding 40" in height with vertical bolt three point locking mechanisms.

H. Acceptable manufacturers: Products of the following manufacturers are acceptable.

2. Cabinets for systems and/or products, use cabinets furnished by manufacturer with system or product. Where system or product cabinets do not comply with these Specifications, submit cabinet shop drawings, indicating deviations, and obtain approval for their use.

2.7 JUNCTION BOXES AND PULL BOXES: UL 50.

A. Provide pull and junction boxes of Code gauge steel sized as indicated or required. Provide 16 gauge steel minimum, unless otherwise noted. Indoor enclosures shall conform to NEMA ICS 6 for the type 1, unless otherwise noted.

B. Size junction and pull boxes to not less than minimum Code requirements. Increase size above Code requirements where necessary to provide space for pulling, racking or splicing enclosed conductors, or where specified or indicated dimensions exceed Code requirements.

C. Fabricate sheet metal junction and pull boxes of galvanized, Code gage, sheet steel. Include angle iron framing where required for rigidity. Boxes shall not deflect or deform visibly when covers are removed after conduit and conductors are installed, and any deflection occurring shall not prevent the easy installation and removal of cover attachment screws.

D. Do not use single covers for junction and pull boxes having cover length or width dimension exceeding three feet unless so specified, indicated, or approved. Sectionalize covers that exceed three feet in either dimension into two or more sections.

E. Equip metal junction and pull boxes exposed to weather (and not installed in or below grade) with raintight or weatherproof removable covers. Enclosures shall conform to NEMA ICS 6 for the type 3R, unless otherwise noted. Rain tight or weatherproof boxes shall be used threaded watertight hubs for top or side entry and may use knockout for bottom entry only. For exterior pull boxes, use a minimum of 14 gage galvanized G-90 grade sheet steel.

F. Use concrete junction and pull boxes for exterior underground conduit unless otherwise specified or indicated. Use steel plate or cast iron covers and rims in no traffic areas, and cast iron covers and rims designed for AASHTO Class H20 wheel loading wherever vehicular traffic will occur.

G. For interior junction and pull boxes located in concrete floors, and 24" square or smaller, use cast iron boxes with integral cast tapped conduit hubs, and having recessed cover flush in the box trim placing all elements of the face of the box flush in the plane of the surrounding floor. Equip boxes with watertight covers where so indicated.

H. For interior pull boxes located in concrete floors and larger than 24" square, use precast concrete boxes or form these boxes at the job site. Equip with angle iron cover rim, and with reinforced steel cover plate set flush with the finish floor plans. Specific plan details shall supersede these general requirements.
I. Equip grade level exterior pull boxes with a sump, and with knockouts for conduit on sides and ends. Coordinate requirements for conduit openings with underground conduit requirements. Identify the covers of exterior grade level junction and pull boxes with the work "ELECTRIC" cast into or otherwise permanently inscribed in the metal of the cover. Equip exterior grade level pull boxes with pull irons where so indicated.

J. Equip surface sheet metal junction and pull boxes with covers aligning with the sides of the boxes and equip flush boxes with covers extending 3/4" all around the perimeter of the back box. Provide sufficient cover attachment screws to ensure that box covers will contact the surface of the box for the entire perimeter of the enclosure. Use galvanized or cadmium-plated screws, or brass screws to attach covers to boxes.

K. Use brass screws to attach junction and pull box covers to interior floor boxes or to boxes located where moisture may be present.

L. Acceptable manufacturers:
   3. Concrete junction and pull boxes: Brooks Products Inc., Quickset Co, or Equal.

2.8 PANELBOARDS
   A. Panelboards: UL 50, UL 67, NEMA PB1, circuit breaker type, size and number of breakers as indicated.
   B. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard. Where isolated ground bus is required, a ground bus shall be mounted on insulators isolated from the enclosure.
   C. Minimum short circuit rating: 10,000 amperes rms symmetrical for 240 volt panelboards; 14,000 amperes rms symmetrical for 480 volt panelboards, or as indicated. Series ratings are not acceptable. Panel boards shall be fully rated for the available fault.
   D. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type, ambient compensated, thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled. Do not use tandem circuit breakers. Where main breaker is shown as non-automatic, it shall be equipped with high magnetic trip with same interrupting capacity as all branch circuit breakers.
   E. Enclosure: NEMA PB 1, Type 1 or as indicated.
   F. Cabinet box: 6 inches deep; width: 20 inches.
   G. Cabinet Front: Flush or surface cabinet front as indicated with concealed trim clamps, door – in – door type, concealed hinge, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

2.9 SAFETY SWITCHES
   A. NEMA KS 1. Switches serving as motor-disconnect shall be horsepower rated. Provide heavy-duty type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches.
Fused switches shall utilize Class R fuseholders and fuses unless indicated otherwise. Unless otherwise indicated, provide indoor switches in NEMA Type 1 enclosure, per NEMA ICS 6. Provide outdoor switches in NEMA Type 3R enclosure, per NEMA ICS 6.

B. Unless otherwise indicated or required, use only unfused type for motor or equipment disconnects. Provide switches for the number of poles and the voltage, current and horsepower ratings as required.

C. Provide each switch with a nameplate indicating equipment controlled.

2.10 WIRE CONNECTORS AND TERMINALS: For use with copper conductors. UL 486A.

2.11 INSULATING TAPES: UL 510.

2.12 NAMEPLATES: Provide as specified in Section 16195, "Electrical Identification."

PART 3 - EXECUTION

3.1 INSTALLATION: Electrical installation shall conform to requirements of NFPA 70, state codes, and to requirements specified herein.

3.2 LOCATIONS

A. The drawings indicate diagrammatically the desired locations and arrangements of the components of the electrical work. Follow the drawings as closely as possible, but use judgement and coordinate with other trades to secure the best possible installation in the available space and under the developed conditions.

B. Before installing any equipment, conduit, or locating any outlet, examine the complete set of documents, including shop drawings and specifications, and verify all dimensions and space requirements. Make such minor adjustments as may be necessary to fit the building structure and accommodate the work of other trades. Install all electrical work to preserve legal headroom, access, work space, clearances and to keep openings and passage ways clear. Arrange for additional space if required for the servicing, maintenance, and replacement of the electrical equipment.

C. Control devices shall not be mounted more than 48" above the floor to the center of the device.

D. Prior to installation, the Owner reserves the right to relocate any outlet or device within six feet of the location indicated on the plans and at no additional cost to the Owner.

E. No additional compensation will be allowed for omissions, inadequate space, misunderstandings or rejected work caused by neglect of these requirements.

3.3 CONDUIT

A. Rigid steel conduit shall be used for following applications:

1. Installations exposed to weather including under canopy and soffit.
2. Wet locations
3. Rigid steel conduit shall not be installed below grade in direct contact with earth.
4. Provide "DANGER - HIGH VOLTAGE" labels on exposed conduits containing circuits greater than 600 Volts. Refer to Section 16195.
5. Mechanical and electrical equipment rooms.
6. Where noted on drawings.

B. Electrical metallic tubing (EMT) shall be installed in indoor dry locations only. Minimum size ¾” restrictions applicable to EMT:
   1. Do not use for feeder circuits.
   2. Do not install below grade.
   3. Do not encase in concrete.
   4. Do not use in areas subject to severe physical damage.
   5. Do not use in hazardous areas.

C. Do not use outdoors.

D. Heavy wall PVC Schedule 40 conduit shall be used for underslab and underground runs. Minimum size shall be 1”. Make all fittings in plastic conduit watertight with solvent-weld cement recommended by conduit manufacturer and specifically manufactured for the purpose. Use a spring mandrel as required to assure full diameter at all bends.
   1. The top of the duct shall not be less than 36 inches below grade.
   2. Risers shall be galvanized rigid steel wrapped in approved black pipe tape.
   3. Refer to Section 16402, "Underground Electrical Work," for site underground duct requirements.

E. Use liquidtight flexible conduit (maximum 6 feet) for final connections to lighting fixtures in accessible ceilings, motors, transformers and other vibration type equipment, or with the approval of the Owner’s Representative, where absolutely necessary due to structural conditions. Provide green ground conductor in all flexible conduit.

F. Install conduit in accordance with NECA "Standard of Installation." The electrical drawings are diagrammatic and do not show all offsets, bends, fittings, junction boxes, pull boxes and expansion fittings required to meet field conditions. Determine actual material and hardware requirements and verify all dimensions by field inspection.

G. Arrange supports to prevent misalignment during wiring installation.

H. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

I. Group related conduits; support using conduit rack. Construct rack using steel channel provide space on each for 25 percent additional conduits.

J. Arrange conduit to maintain headroom and present neat appearance.

K. Route exposed conduit parallel and perpendicular to walls.

L. Maintain adequate clearance between conduit and piping.

M. Maintain 12 inch clearance between conduit and surfaces with temperatures exceeding 104 degrees.

N. Cut conduit square using saw or pipecutter; de-burr cut ends.
O. Bring conduit to shoulder of fittings; fasten securely.

P. Provide pull fittings in all overhead conduit runs exceeding 200 feet of straight conduit, or having more than the equivalent of three 90 degree bends. Each 90 degree bend shall be considered the equivalent of 50 feet of straight run. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one-shot bender to fabricate or factory elbows for bends in metal conduit larger than 2 inch size.

Q. Where conduit passes from one type of construction to another, or where there is a possibility of dissimilar movements, an expansion/deflection device or a suitable loop of seal tight flexible conduit shall be installed. Looped seal tight flexible conduit shall consist of 18” minimum length of looped conduit with a junction box at one or both ends, wherever conduit crosses building seismic joints.

R. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

S. Conduit which penetrates fire walls, fire partitions, or floors shall be metallic on both sides of fire walls, fire partitions, or floors for minimum distance of 6 inches. Restore fire rating integrity at conduit penetration. All holes created to extend electrical systems through fire rated floors and walls shall be sealed by the contractor with an intumescent material capable of expanding up to 8 to 10 times when exposed to temperatures beginning at 250°F. It shall be UL Classified and have I.C.B.O., B.O.C.A.I. and S.B.C.C.I. (NRB 243) approved ratings to three hours per ASTM E-814 (UL 1479).


T. Where conductors of No. 4 AWG or larger are to be installed in a conduit, or where any conductors are to be deflected more than 30 degrees when leaving a conduit, terminate the conduit with an insulating bushing.

U. Ground and bond conduit under provisions of Section 16170.

V. Pull wires. Provide a 1/8” size polypropylene pull wire in all empty conduits up to 2”, including those for signal and telephone system. Pull cord in conduits (2” and larger) shall be 3/16” size. Identify conduits at exposed ends with tags. Tags shall identify location of other end of conduit. The pull wire shall be left with more than 5 feet in length at both ends for future use.

3.4 600 VOLT CONDUCTORS

A. Splices:

1. Splices in conductors #8 AWG and smaller shall be made with "Scotchlok" insulated connectors or equal (no known Equal) of proper size for conductors being spliced.

2. Splices in conductors #6 AWG and larger shall be made with pressure type solderless connectors. The splice area shall be taped to provide equal or greater insulation than the original. Tape runback over the original insulation shall extend 3 to 5 overall diameters of the insulated wire.

B. Connectors and terminal lugs shall be used for terminating stranded conductors #6 AWG and larger and shall be T&B, Ilsco, or Equal solderless connectors.

C. Wire in panels, cabinets, pull boxes and wiring gutters shall be neatly grouped, strapped together with T&B Model Tyrap cable strap, or equal (no known equal), or laced with #12 stranded lacing twine and fanned out to the terminals.
D. Neutral conductor shall be continuous in outlet boxes and shall not be broken by addition or removal of devices.

E. Wiring methods in return air plenum spaces shall comply with NEC 300-22.

F. Splices in underground pull boxes and hand holes shall be made using epoxy kit made by ‘3M’ or equal (no known equal).

3.5 FITTINGS

A. Use threaded fittings for rigid metal conduit and compression fittings for electrical metal tubing (EMT).

B. Use cement-on fittings for plastic conduit.

C. Fittings for flexible conduit shall be of the threadless hinged clamp type. Do not use fittings threaded internally into the flexible conduit ends.

D. Use fittings made of the same material as the raceway except:
   1. Malleable iron and steel are interchangeable.
   2. Die cast fittings may be used for flexible steel conduit and for factory manufactured offsets.
   3. Use aluminum fittings only with aluminum conduit.
   4. Use plastic insulated bushings for conduit sizes larger than 1".
   5. Use insulated throat connectors for electrical metallic tubing.

3.6 CABINETS

A. Set cabinets at heights indicated or specified. In the absence of such information, set cabinets at not to exceed 6'-6" from finish floor to top of cabinet.

B. Align tops of cabinets in sight of each other at a uniform height.

C. Install cabinets and other enclosure products in plumb with the building construction. Install flush enclosures so that the trim will rest against the surrounding surface material around the entire perimeter of the enclosure.

D. Where cabinets are located in poured-in-place concrete wall construction, brace internally with temporary wood or other bracing to prevent deformation of the back or sides of the enclosure.

E. Do not locate cabinets (or other electrical enclosures) where room doors will touch enclosure face when room door is opened 180°. Locate cabinets (and other enclosures) so that enclosure door can be opened through a minimum 180° arc, except that the arc may be reduced to 130° for enclosures mounted to wireways. Do not install surface mounted cabinets in finished areas, unless so indicated. Where conflicting data is indicated, verify mounting requirements prior to ordering cabinets.

3.7 WIRING DEVICES

A. Use products of a single manufacturer for each type of wiring device. Different manufacturers may be used for different type devices, if the requirements of the specification are fulfilled.
B. Use the products of a single manufacturer for all device plates. Obtain prior approval for any variations from this requirement except that plate variations are allowed for the following devices:

1. Where the selected plate manufacturer does not manufacture a suitable finish plate.
2. For heavy-duty receptacles rated at more than 30 amperes.
3. Where the raceway system enclosure employs a non-standard finish plate.
4. Where non-standard plates are specified or indicated.

C. Position receptacles so that the ground contact in grounding type receptacles is on top of parallel prongs.

D. Install adjacent devices of the same type and with the same mounting height in a common outlet box.

E. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with specialty building equipment requiring very exact electrical rough-in.

3.8 BOXES, OUTLETS AND SUPPORTS: Provide boxes in wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when installed exposed up to 7 feet above interior floors, when installed under raised floor or when installed in hazardous areas. Boxes in other areas shall be sheet steel. Each box shall have volume required by NFPA 70 for number of conductors enclosed in the box. Provide gaskets for cast-metal boxes installed in wet locations.

3.9 JUNCTION AND PULL BOXES

A. Wherever possible use outlet boxes for junction and pull boxes.

B. Locate interior junction and pull boxes in machine rooms, equipment rooms, storage rooms, electrical rooms and similar utility spaces unless otherwise indicated or approved. Where junction or pull boxes must be used in finished areas, use flush boxes only equipped with prime finished sheet metal plates. Fasten plates to boxes with countersunk flat head screws. Provide plates with 3/4" trim all around.

C. Do not use sectionalized boxes except where indicated. Do not mix feeder and branch circuit conductors in a common pull or junction box.

D. Where more than one circuit passes through a common junction or pull box, tag conductors to indicate circuit number and panel designation.

3.10 OPENINGS, CHASES AND SLEEVES

A. Provide openings, chases, cutting, patching, sleeves and other products, necessary to permit the electrical raceways and cables to pass through the structure.

B. Establish locations for openings, chases and sleeves sufficiently in advance of construction to avoid cutting and patching. Perform any required cutting and patching for electrical work and obtain approval for cutting from Owner’s Representative prior to work being done.

C. Repair damages to finished work and surfaces caused by cutting, to the satisfaction of Owner.
D. Install sleeves wherever raceways of any type pass through walls or floors above grade, except that sleeves are not required for drywall construction or laid up masonry construction used for interior partitions and not fire rated.

E. Use pipe or sheet steel sleeves for interior dry locations.

F. Install sleeves with both ends flush with wall surfaces and with upper ends 3" above floor surfaces. Install bottom end of floor sleeves flush with slabs if not concealed by ceiling system. Use steel pipe sleeves through floors.

G. Furnish galvanized steel 24 gauge roof jacks and pitch dams for roof penetrations. For installation of roof jacks and pitch dams (pockets), refer to Architectural drawings. Size roof jacks to extend 6" out on roof and 8" up conduit above roof. Solder or braze a flashing collar to conduits passing through roof jacks. Size pitch dams to extend 6" above roof and 6" beyond roof opening.

H. Core drill existing concrete walls or slabs to pass new runs of conduit or tubing. Seal core drilled openings as described for sleeves.

I. For exterior walls below grade conduit entries, use manufacturer fabricated wall entrance seals.

3.11 PANELBOARDS

A. Install panelboards in accordance with NEMA PB 1.1 and NECA Standard of Installation.

B. Align and level panelboards and securely fasten to the building. Do not use connecting conduits to support the panelboards. Install trim plumb and square.

C. Height: 6 ft to top of panelboard; install panelboards taller than 6 ft with bottom no more than 4 inches above floor.

D. Provide filler plates for unused spaces in panelboards.

E. Provide typed circuit directory for each branch circuit panelboard affected by work under this contract. Revise directory to reflect circuiting changes required to balance phase loads.

F. Provide engraved plastic nameplates under the provisions of Section 16195.

3.12 MOUNTING HEIGHTS: Mount disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor or platform. When installing switch next to existing switch, match mounting height of existing switch.

3.13 FIELD TESTS: Refer to Section 16030, "Acceptance Testing," for additional requirements. The contractor shall provide all test equipment and personnel and submit written copies of all test results.

A. Distribution Conductors, 600 Volt Class: Test all conductors #10 AWG and larger to verify that no short circuits or accidental grounds exist. Tests shall be made using an instrument which applies a voltage of approximately 500 volts and providing a direct reading of resistance in ohms. Insulation resistance, corrected to 60°F, shall not be less than the following values:

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>250-750 kcmil</td>
<td>50 megohms</td>
</tr>
<tr>
<td>4-4/0 AWG</td>
<td>50 megohms</td>
</tr>
</tbody>
</table>
BASIC MATERIALS AND METHODS

16050 - 14

10-6 AWG 100 megohms

Record resistance readings, temperature and weather conditions on the test form.

B. Operational Tests: Demonstrate the operation of each switch, relay and other item of electrical control with the system fully energized and operating. Each shall be demonstrated three times. Any faulty or defective Contractor furnished materials and workmanship found during the tests shall be replaced or corrected by the Contractor at no additional cost to the Owner.

END OF SECTION 16050
PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. The cable shall be copper, 15 KV (size as indicated on the drawings) EPR insulation jacketed, shielded. Aluminum cable will not be accepted.

1.2 STANDARDS

A. ICEA S-68-516
B. AEIC C56
C. UL 1072
D. IEEE
E. ASTM
F. NEMA

Material and installation shall meet or exceed the above referenced standards.

1.3 QUALITY ASSURANCE

A. The manufacturer shall have a minimum of ten years of experience in manufacturing medium voltage EPR power cables and shall submit a certified copy of its AEIC CS 6 qualification.

B. American made cable has been acceptable to the Owner. If non-domestic cabling is submitted, notice is hereby given that extensive testing shall be required to insure quality and conformance to the Specifications. All of the testing procedures and results shall be satisfactory to the Owner.”

C. Testing: Provide the services of a qualified testing laboratory to perform the specified field tests. Notify the Owner's Representative 14 days in advance of performance of Work requiring testing. Refer to Section 16030 regarding additional requirements.

D. Manufacturer shall have ISO – 9001 Certification.

E. The cable manufacturer shall compound the insulation in its own facility using a closed system to insure maximum cleanliness. All ingredients shall be mixed and screened through a fine mesh screen pack. Materials shall be stored in a Class 10,000 clean room.

1.4 SUBMITTALS

A. Shop Drawings
B. Complete data sheet for cable construction, shielding, insulation material, thickness of insulation and jacket cable stranding and voltage rating, total amount of order in feet, including manufacturer’s AEIC CS 6 qualifications.

C. Manufacturer’s ISO certification.

D. Certified test reports for:

1. Sample test on insulation: physical properties, solvent extraction, heat distortion, and accelerated water absorption.
2. Factory test for insulation resistance, power factor corona level, AC dielectric.
3. Certified Factory Test Report including the results of the test plus cable identification, factory order number, cable length and all cable specifications. No cable shall be installed in any duct or conduit until related test report has been accepted by the Owner's Representative.
5. Qualifications of "Cable Splicers"

Submit a certification for the approval of the Owner's Representative containing the names and the qualifications of persons recommended to perform the splicing and termination of medium voltage cables approved for installation. Refer to Section 01400 including Exhibit "A" for certification requirements and information regarding cable installation termination and testing.

6. Factory Tests

A complete test shall be done on each length of cable at the factory in accordance with ICEA S-68-516, and UL-1072. In addition a corona test shall be done per AEIC CS6-87, Section E.

Cable Sample:

Furnish a 2 feet sample of actual cable to be used on this project. Sample shall be submitted to the Owner’s Representative for review (14) days prior to shipment of cable by the manufacturer.

PART 2 - MATERIALS

2.1 MEDIUM VOLTAGE CABLES

A. General:

1. 15KV ungrounded, shielded, single copper conductor, UL listed Type MV105, with ethylene-propylene (EPR) insulation, jacketed. Manufactured within one year of installation.
2. Suitable for installation in conduit, subject to alternately wet and dry conditions.
3. To operate satisfactorily, both electrically and mechanically, at conductor temperatures not exceeding 105 Deg. C continuous for normal loading; 130 Deg. C for emergency loading, emergency of 36 hours, 250 Deg. C for short circuit loading assuming a short circuit duration of two seconds. Emergency overload operation may occur for periods up to 100 hours per year and with as many as five (5) such 100 hour periods within the lifetime of the cable.
4. Cable to meet the specifications and the minimum requirements of the latest revisions of ICEA and AEIC Standards.

B. Conductors: Soft, annealed copper, concentric compact Class B stranded per ASTM B-8.
C. Strand Shielding: Thermoset EPR based material or a material extruded over the conductors with thermal characteristics equal to or better than those of the insulation; chemically compatible with the conductor and the cable insulation; firmly and continuously bonded to the overlying insulation; easily removable from the conductors; not less than 25 mils or more than 50 mils thick. Compatibility of material shall be demonstrated by laboratory test results.

D. Insulation: High quality, ethylene-propylene base, thermosetting compound of high dielectric strength with heat, moisture, ozone, and corona resistant properties, homogenous, solid, and applied with good workmanship. Insulation thickness shall be 115 mils minimum average, and 110 mils minimum at any point; meet or exceed the latest editions of Standards ICEA S-68-516, AEIC CS-6 for 133% insulation lever. EPR insulation compound shall contain no polyethylene.

E. Semi- Conducting Shield: Insulated conductor to have a suitable layer of semi-conducting, extruded, thermosetting, polyethylene insulation shielding applied directly over the insulation; 50 mils average thickness; 45 mils minimum thickness; impervious to sunlight, the elements and acid or alkaline soils.

F. Shielding Tape: Uncoated copper tape, helically applied over insulation .005 inch thick with minimum 25% overlap.

G. Jacket: 80 mil, minimum average thickness polyvinyl chloride jacket extruded over the shielding tape; smooth, of uniform composition and free of holes, cracks and imperfections; longitudinal shrinkage relative to the insulation less than five percent.

H. Construction: Strand shielding insulation and semi-conducting insulation shield shall be applied in a continuous triple-tandem extrusion process.

I. Identification: Provide durable lifetime identification printed, embossed, or engraved on outer surface of the jacket including manufacturer's name, year of manufacture, place of manufacture, conductor type and size, insulation thickness in mils, and the rated voltage, all on 3 foot center maximum spacing.

J. Sealing: Seal ends of cable with mastic material and tight fitting plastic end cap to prevent entrance of moisture.

K. Manufacturers: General Cable, Okonite, or Kerite

2.2 CABLE TERMINATIONS

A. 15 KV conductor terminations shall be IEEE 48, Class 1, shrinkable rubber or polymeric cable termination in kit form with ground clamp, non-tracking skirts, moisture-blocked ground braid and auxiliary materials; rated for voltage class of cable being terminated, as manufactured by 3M, Elastimold or equal.

2.3 ARC AND FIREPROOFING TAPE

A. Manufacturers:

1. Bishop Model 43A,
2. 3M Model 7700, or equal.
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BAKERSFIELD, CA  

PART 3 - EXECUTION

3.1 PREPARATION

A. Use swab to clean conduits and ducts before pulling cables.

3.2 INSTALLATION

A. Install cable and accessories in accordance with manufacturer's instructions.

B. Avoid abrasion and other damage to cables during installation.

C. Use suitable lubricants and pulling equipment.

D. Do not exceed cable pulling tensions and bending radius.

E. Ground cable shield at each termination and splice. Conductor shield continuity must be maintained at all splices.

F. Fireproof cables in main 15kV switchgear vault using fireproofing tape in half-lapped wrapping. Extend fireproofing one inch into duct. Use spiral wrap fireproofing glass tape, 3M number 27 or equal (no known equal).

G. All cables shall be tagged with laminated Micrata type nameplates engraved with 5/32-inch high white letters on black background, showing the size of the cable, what the cable feeds and the date it was first energized. The tags shall be attached to the cables with heavy duty nylon ties and shall be located in every pullbox, junction box, etc., and at every splice and termination. The cables shall also be phase marked "A", "B", and "C".

H. The cables shall be terminated, and spliced as shown on drawings with self-vulcanizing tapes in accordance with the printed instructions of the manufacturer of the cable supplied. All self-vulcanizing tapes used to provide the cable insulation shall have an EPR base.

I. Single conductor cables in gutters or wireways, or racks in vaults, shall have the three conductors or each circuit bound together with plastic cable ties at point not over three feet apart.

J. Stress cones shall be made on all cable splices and terminations, and shall be made in accordance with the printed recommendations of the cable manufacturer.

K. The conductor shields shall be grounded at each termination of the cable run, and on both sides of all splices, using a stranded, #4/0 bare copper wire to the nearest ground system. Conductor shield continuity must be maintained at all splices. The ground wire shall be protected from mechanical injury by enclosing it in a metal protective covering or by placing it where it will not be subject to damage.

L. L. Provide one THWN insulated ground conductor in each conduit with phase conductors. Size of the ground conductor shall be as shown on the drawings.

3.3 FIELD TESTS:

A. Testing of cables shall be performed by an independent testing agency at the Contractor's expense. The testing agency shall have a minimum of 5 years experience. Each person engaged in the testing proce-
B. Perform DC high potential test of each conductor in accordance with the latest NETA standards.

C. Connect untested conductors in circuit to ground during test.

D. Apply test voltage in at least eight equal increments to maximum test voltage.

E. Record leakage current at each increment, allowing for charging current decay.

F. Hold maximum test voltage for fifteen minutes. Record current at 30 seconds and every 60 seconds thereafter. Plot results on X-Y axis.

G. Each insulated conductor provided under this section of the Specification shall be tested in accordance with Section E of AEIC CS6.

H. Cable splices and terminations shall be tested as an assembly.

3.4 PROTECTION

A. Protect installed cables from entrance of moisture. Provide heat shrink caps per Cable Manufacturer's recommendations for cables to be energized later on.

END OF SECTION 16122
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SECTION 16170 – GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies grounding electrodes and conductors, grounding electrodes, equipment grounding conductors and bonding.

1.2 RELATED SECTIONS

A. Section 16010 - Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

B. Section 16030 - Electrical Acceptance Testing

C. Section 16050 - Basic Materials and Methods

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute (ANSI) Publication:

B. Institute of Electrical and Electronic Engineers (IEEE) Publication:
   1. 142-1991 Recommended Practice for Grounding of Industrial and Commercial Power Systems

C. National Fire Protection Association (NFPA) Publication:
   1. 70-99 National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (U.L.) Publication:
   1. 83-91 Thermoplastic Insulated Wires
   2. 467-93 Grounding and Bonding Equipment

1.4 SUBMITTALS

A. Product Data: Provide data for the following:

   1. Grounding electrodes
   2. Precast ground wells
   3. Ground bus bars
   4. Conductors
   5. Connections (all types)
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BAKERSFIELD, CA

B. Test Reports: Provide reports for the following:
   1. Indicate overall resistance to ground and resistance of each exposed electrode.

C. Manufacturer's Instructions: Include instructions for storage, handling, protection, examination, preparation and installation of exothermic connectors.

1.5 PROJECT RECORD DOCUMENTS

A. Accurately record actual locations of grounding electrodes.

B. Accurately record signal ground wire pathways, points of bonding, and point of connection to building grounds.

C. Protector grounding shall indicate ground source, distance, and size of ground wire.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70 and ANSI C2.

B. Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to Owner as suitable for purpose specified and shown.

1.8 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: Maximum 5 ohms unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated. Except where specifically indicated otherwise, provide only new materials having all legally required approvals and/or labels. Materials shall conform to the requirements of UL 467 where applicable.

2.2 ROD ELECTRODE

A. Material: Copper-clad steel.

B. Diameter: 3/4 inch, unless otherwise indicated.

C. Length: 10 feet, unless otherwise indicated.
2.3 CONDUCTOR, UL 83

A. Ground and bonding conductors shall be green-insulated, soft-drawn stranded copper conductors, unless otherwise indicated, installed with sufficient slack to avoid breaking due to settlement and movement of conductors or attached points.

B. System grounding conductors shall be minimum of 4/0 AWG copper, unless otherwise indicated, and shall be continuous with no joints or splices.

2.4 CONNECTORS AND TERMINALS

A. Wire Connectors and Terminals for use with Copper Conductors: UL 486A.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION: Provide grounding and bonding in accordance with the requirements of NFPA 70, IEEE 142, EIA/TIA 568, EIA/TIA 607, state codes and to requirements specified herein. Codes shall be complied with as a minimum requirement with specifications prevailing when they are more stringent.

A. Grounding Electrode System:

1. The grounding electrode system at each new substation and building shall be in strict accordance with requirements as indicated on the drawings.

2. Install rod electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground.

3. Where indicated, the point of connection of the ground conductor to the grounding electrode shall be mechanically protected in a concrete box with a removal cover plate marked: "Grounding Electrode" and shall be visible for inspection. Provide crushed rock in the bottom of the box - 18" in depth.

4. Grounding connections which are buried or otherwise normally inaccessible, and excepting specifically those connections for which periodic testing is required, shall be made by exothermic type process weld (Cadweld, Thermoweld or equal). Make thermit welds strictly in accordance with the weld manufacturer's written recommendations. Welds which have "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable.

5. Transformers, emergency systems, and other isolated system neutrals shall be grounded from the neutral bushing or connector to a continuous metallic cold water main or to building steel where available and solidly grounded to ground electrode.

6. Connect to existing grounding electrode system in existing buildings or substations. Contractor shall test existing electrode system. Report to Owner’s Representative any resistance to ground values exceeding 5 ohms.

B. Bonding

1. Metallic conduits, wireways, metal enclosures of busways, cable boxes, electrical equipment housings, cable racks in manholes and all non-current carrying metallic parts shall be grounded. The metallic conduit system shall be used for equipment and enclosure grounding but not as a
system ground conductor. Include a code sized green insulated copper grounding conductor in nonmetallic conduits and terminate each end on suitable lug, bus, or bushing.

2. All conduit stub-ups shall be grounded and where multiple stub-ups are made within an equipment enclosure, such as a switchboard, they shall be equipped with grounding bushings and bonded together and to the enclosure and the enclosure ground bus.

3. Bond together each metallic raceway, pipe, duct and other metal object entering the new buildings. Use 2 AWG bare copper conductor.

C. Equipment Ground

1. All feeder conduits and branch circuit wiring conduits shall carry a green THHN/THWN insulated code sized ground conductor properly connected for electrical ground continuity. Provide an equipment ground conductor for no more than three (3) feeder conductors or three (3) branch circuit conductors unless otherwise noted.

2. Flexible conduit shall not be used as a ground path. Include code sized green conductor in all flex conduit.

3. Provide bonding devices, fittings or jumpers at expansion fitting, isolation sections or wherever continuity of ground is broken.

3.3 FIELD TESTS: Refer to Section 16030, "Electrical Acceptance Testing," for additional requirements. The contractor shall provide all test equipment and personnel and submit written copies of all test results.

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

B. Provide personnel and test equipment to measure the resistance to ground of the grounding system before connecting equipment. Resistance to ground using the 3-point, fall-of-potential test method shall not exceed 5 ohms unless otherwise noted. Record resistance measurements, test point locations, ambient temperature and weather conditions at time of test.

END OF SECTION 16170
PART 1 - GENERAL

1.1 DESCRIPTION

A. Electrical connections to equipment specified under other sections.

B. Examine Contract Drawings and other Divisions of these Specifications to ascertain the extent of powered equipment covered by the Drawings and Specifications and the methods by which each item of equipment will be furnished, delivered to the site, and installed and the amount of electrical work required for each item of powered equipment.

1.2 RELATED SECTIONS

A. Section 01010 - Summary of Work

B. Electrical work for powered equipment specified in other Divisions of these Specifications.

C. Section 16010 - Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

D. Section 16050 - Basic Materials and Methods.

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. National Electrical Manufacturers Association (NEMA) Publications:

1. WD 1 General Purpose Wiring Devices
2. WD 6 Wiring Device Configurations

B. National Fire Protection Association (NFPA) Publication:

1. 70 National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submit under provisions of Sections 01300.

B. Submit layout shop drawings only for areas with deviations from design drawings.

C. Powered equipment suppliers shall furnish, in addition to the manufacturer's data specified in other Sections, the following:

1. Wiring diagrams.
2. Operating Sequences.
3. Installation layouts.
4. Electrical load, voltage and phase data.
5. UL Listing.

1.5 GENERAL REQUIREMENTS

A. Provide the products, and execute the work for this Section in accordance with the product and execution requirements, where applicable, as set forth in the other Sections of Division 16, to provide a complete functional electrical system.

1.6 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

1.7 COORDINATION

A. Obtain and review shop drawings, product data, and manufacturer's instructions for equipment furnished under other sections.
B. Determine connection locations and requirements.
C. Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.
D. Sequence electrical connections to coordinate with start-up schedule for equipment.

1.8 ELECTRICAL WORK FOR POWERED EQUIPMENT

A. Disconnect switches in general shall be furnished and installed as electrical work where indicated or required, except where integrally mounted on "package units" provided by other trades.
B. Provide all starters, combination and magnetic, in motor control centers and individually located, except "chiller" starters and starters in "package units". Starters for three-phase equipment shall be combination type. Magnetic starters shall be used for all single-phase equipment requiring remote control.
C. Provide manual starters for 120 volt single phase motors except starters supplied with package units.
D. Provide all power wiring to all powered equipment installed on this project and included in any section of the Contract Specifications, except as specified in Section 15975, "Direct Digital Control Systems". Power wiring shall be defined as conductors, conduit, enclosures and connections and related electrical work to supply powered equipment and including electrical power to supply point for powered equipment control systems.
E. Do not order motor controllers or motor control centers until requirements for auxiliary contacts and final motor sizes are verified.

1.9 SUBSTITUTIONS: When powered equipment other than that originally specified or indicated is approved for use at the contractor's request, then the contractor shall be responsible for any costs incurred
by other trades, including revisions to the electrical work such as electrical power supply, wiring, disconnects, circuit breakers, etc.

PART 2 - PRODUCTS

2.1 CORDS AND CAPS

A. Attachment Plug Construction: Conform to NEMA WD 1.

B. Configuration: NEMA WD 6; match receptacle configuration at outlet provided for equipment.

C. Cord Construction: ANSI/NFPA 70, Type SO multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.

D. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Coordinate electrical connections to equipment with other trades under provisions of Section 16010.

B. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using liquidtight flexible conduit with watertight connectors.

C. Make wiring connections using wire and cable with insulation suitable for temperatures encountered in heat producing equipment.

D. Provide receptacle outlet where connection with attachment plug is indicated. Provide cord and cap where field-supplied attachment plug is indicated.

E. Provide suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

F. Install disconnect switches, controllers, control stations, and control devices as indicated.

G. Modify equipment control wiring with terminal block jumpers as indicated.

H. Provide interconnecting conduit and wiring between devices and equipment where indicated.
3.3 EQUIPMENT SCHEDULES: Refer to architectural, mechanical and plumbing drawings for equipment schedules. Provide all power wiring to all powered equipment installed on the construction project and included in any section of the specifications.

END OF SECTION 16180
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SECTION 16195 – ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies nameplates and labels, wire and cable markers, medium voltage cable tags, underground warning tape, conduit markers and warning signs.

1.2 APPLICABLE PUBLICATIONS: The following publications form a part of this specification. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute, Inc. (ANSI) Publications:
   3. Z35.2-97 Environmental and Facility Safety Signs
   4. Z35.5-97 Accident Prevention Tags (for Temporary Hazards)

B. State of California Code of Regulations:
   1. Title 8, Industrial Relations

C. National Fire Protection Association (NFPA) Publication:
   1. 70-99 National Electrical Code (NEC)

1.3 SUBMITTALS

A. Product Data: Provide data for:

   1. Nameplates
   2. Wire/Cable markers
   3. Medium voltage cable tags
   4. Underground warning tape
   5. Conduit markers

B. Field Samples: Provide for:

   1. Nameplates: (1) sample
   2. Wire/Cable markers: (2) samples
   3. Medium voltage cable tags: (1) sample
   4. Underground warning tape: (1) sample, 24" long
   5. Conduit markers: (1) sample
1.4 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Nameplate designations shall clearly state:

1. Manufacturer's nameplate including equipment design rating of current, voltage, kVA, HP, bus bracing rating, or as applicable.
2. Equipment nameplate designating system usage and purpose, system nominal voltage, equipment rating for kVA, amperes, HP and RPM as applicable.
3. Contactors: Voltage, continuous current, horsepower or interrupting current, and whether "mechanically-held" or "electrically-held".

B. Nameplates shall be melamine plastic, 0.125-inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering into the black core. Minimum size of nameplates shall be 1.0 inch by 2.5 inches except that wiring device nameplates shall be 0.5 inch by 1.5 inch. Lettering shall be normal block style unless otherwise noted.

C. Letter Size:

1. Use 0.25 inch letters for identifying individual equipment and loads.
2. Use 0.50 inch for identifying grouped equipment and loads.
3. Use 1.00 inch for identifying large equipment e.g. medium voltage switches, transformers.

2.2 WIRE MARKERS


B. Legend:

1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
2. Control Circuits: Control wire number indicated on schematic or interconnection diagrams on shop drawings.

2.3 MV CABLE TAGS

A. Identification tags shall be engraved laminated plastic connected to the cable by means of self-locking cable ties. Tags shall contain the following information:

1. Feeder Number
2. Cable start point
3. Cable destination
4. Cable quantity, size, insulation and voltage
5. Date installed (if new)
6. “Emergency Power” for cables connected to emergency power
B. Cable tags shall be melamine plastic, 0.125-inch thick x 2.5" x 5.0", white with black center core for normal power and red with white center core for emergency power. Surface shall be matte finish. Corners shall be square. Accurately align lettering into the black core. Lettering shall be 0.25" high normal block style unless otherwise noted. Verify exact requirements with Owner’s Representative in the field.

2.4 UNDERGROUND WARNING TAPE: The tape shall be continuous 6" wide polyethelene plastic with a metallic core detection tape. The tape shall be color coded red for electric lines and orange for communication lines with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. The imprint shall read "caution (type of utility) line buried below". Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill.

2.5 CONDUIT MARKERS: ANSI Z35.1 G.2. Pressure-sensitive, adhesive-backed vinyl markers with fade-proof ultraviolet inhibitors, black characters on orange background. 2.25" x 9" marker with 1.5" high letters. Marker shall read "4160 VOLTS" or "12000 VOLTS" depending on circuit phase-to-phase voltage. Carlton industries Type EM-1, Seton code electrical markers style AA or equal.

2.6 WARNING SIGNS: ANSI Z35.1.

A. Warning signs shall be minimum 18 gauge steel white porcelain enamel finish with red lettering. Lettering to read "DANGER - HIGH VOLTAGE" "KEEP OUT" with "DANGER" in 1-1/2" letters and "HIGH VOLTAGE" "KEEP OUT" in 1" letters. New warning signs shall be provided on door/gate or immediately above door of all electrical equipment rooms, vaults, closets or outdoor substations containing equipment energized above 150 volts to ground, except where such spaces are accessible from public areas.

B. Warning designations in 1" red letters shall be OSHA approved pre-printed adhesive on each new pull box or cabinet stating "DANGER-KEEP OUT" and giving voltage of enclosed conductors such as "DANGER - 12,000 VOLTS", for all systems over 150 volts to ground. Nameplates shall be attached using cadmium plated screws.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive nameplates and labels.

3.2 NAMEPLATES

A. Provide laminated plastic nameplates for all Owner furnished and contractor furnished electrical equipment and devices including, but not limited to, the following:

1. Enclosures for switchgear, medium voltage controllers, transformers, low voltage switchgear, motor control centers, variable frequency drives, panels, panelboards, busway, pull boxes, junction boxes, cabinets and electronic circuit monitors.

2. Enclosures for all separately enclosed devices including but not limited to disconnect switches, circuit breakers, contactors, time switches, control stations and relays.
3. Special systems such as but not limited to telephone, warning and signal systems. Identification shall be at each equipment rack, terminal cabinet, control panel, annunciator, and pull box.

4. Devices mounted within and part of an equipment including circuit breakers, switches, control devices, control transformers, relays, indication devices and instruments.

B. Mounting: Provide number, location, and letter designation of nameplates as indicated. Install nameplate parallel to equipment lines. Fasten nameplates to enclosures with a minimum of two sheet-metal screws or two rivets. Fasten nameplates to device plates with suitable adhesive. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.

C. Nameplates for panelboards, switchboards and transformers shall include:

Designation of panel, e.g. “1HA1”

Rating: e.g. 400A, 480/277, 3PH, 4W

Fed From:

Manufacturer’s serial number:

Date of installation:

3.3 WIRE MARKERS: Provide markers for each conductor at panelboard gutters, pull boxes, junction boxes, outlet boxes, and each load connection.

3.4 MV CABLE TAGS: All new cables installed shall be identified at each end and at all accessible points in between (such as manholes, pull boxes, switchgear, etc.). Identify existing cables that are being re-routed or changed with new tags. Modification of existing tags shall not be acceptable. Description on tags shall be as directed by owner’s representative.

3.5 CONDUIT MARKERS: Provide markers on all exposed conduit containing conductors with ratings greater than 600 volts. Provide markers at lengths not greater than 20 feet on center.

3.6 WARNING SIGN MOUNTING: Signs shall be permanently mounted with cadmium plated steel screws or nickel-plated brass bolts.

END OF SECTION 16195
SECTION 16322 - SECONDARY UNIT SUBSTATION

PART 1 - GENERAL

1.1 SCOPE

A. Furnish labor and related materials, appliances, tools and equipment necessary for and incident to performing all operations in connection with furnishing, delivery, installation, and start-up of Secondary Unit Substations. The materials herein shall be of new and domestic manufacturer. The substation shall be designed, tested, assembled, and furnished in accordance with the applicable standards.

B. All power distribution equipment shall be of same manufacturer as the substation manufacturer.

C. The substation shall be an integrated assembly of a single manufacturer. Major components shall bear the label of a single manufacturer and shall be assembled in that manufacturer’s plant(s).

D. The contractor shall be responsible for verifying physical space constraints, clearances, and layouts prior to shipment.

E. The substation shall be comprised of:
   1. Primary sections(s)
   2. Transformer section(s)
   3. Secondary sections(s)
   4. Enclosure
   5. Ancillary systems and devices

F. Refer to Construction documents and specifications herein for arrangement of components.

1.2 REFERENCES

A. The substation and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and ANSI.

1.3 SUBMITTALS

A. Submit shop drawings per Section 1340 for review including the following as a minimum:

1. Manufacturer Qualifications.
2. Substation shop drawings from the manufacturer showing single line diagram, elevation, plan, overall dimensions, weights, layout of components and devices, enclosure type, short circuit withstand ratings, seismic calculations, nameplate schedule, interconnecting wiring diagrams, rated voltage, rated current, and conductor sizes.
3. Layout of substation in room area, or yard to scale including horizontal and vertical clearances.
4. Seismic calculations, signed and stamped by a California Registered Structural Engineer.
5. Installation instructions.
6. Manufacturer’s technical cut sheets and catalog cuts for primary switch, transformer, secondary
ART CENTER AND SATELLITE COOLING PLANT  
CALIFORNIA STATE UNIVERSITY, BAKERSFIELD  
BAKERSFIELD, CA

main circuit breaker, secondary distribution board, feeder devices, instrumentation, surge protection, heaters and other components.

7. Factory test results. Submit within two (2) weeks of completion of tests.

B. One on the following Contractor shall verify interrupting ratings of protective devices from the short circuit study prior to furnishing the submittals to the College.

1.4 SUBMITTALS -- FOR INFORMATION

A. When requested by the College’s Representative the following product information shall be submitted:

1. Descriptive bulletins
2. Product sheets.

1.5 SUBMITTALS -- FOR CLOSE-OUT

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in section 1.04
2. Wiring diagrams
3. Certified production test reports
4. Installation information

B. Submit ten (10) copies of the above information.

1.6 QUALIFICATIONS

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the College’s Representative, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.7 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.8 FIELD MEASUREMENTS

A. Measure primary and secondary voltages and make appropriate tap adjustments.

1.9 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment operation and maintenance manuals shall be provided.

B. Operation and maintenance manuals shall include the following information:
1. Instruction books and/or leaflets
2. Recommended renewal parts list

1.10 FACTORY TESTING

A. The following standard factory tests shall be performed on all equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connections.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are Square D, GE, Cutler Hammer or equal.

2.2 GENERAL

A. The secondary unit substation shall be front and rear aligned and arranged as indicated on the Construction Documents.

B. Primary switch and protective devices in secondary section of the unit sub-station shall have an interrupting rating (AIC) 110% of the maximum short circuit current available at the device or equipment as a minimum. Continuous, momentary, short time symmetrical and asymmetrical fault currents shall be indicated. Series ratings are not acceptable.

C. All major components such as primary switch, transformer and secondary section shall have the same color finish as indicated.

D. Overall substation dimensions shall be as shown on the drawings.

2.3 PRIMARY SECTION

A. A duplex fused load interrupter air switch shall be provided integral to the Secondary Unit Substation where noted on drawings.

B. Ratings and construction shall be as follows:

1. Floor standing, 90” height section.
2. Metal enclosed with minimum 11-gauge steel.
3. Enclosure: NEMA 1 for interior application.
4. 600A continuous rating.
5. 15000V rating, 95kV BIL.
6. Air insulated.
7. Current limiting fuse (class CLE) size as indicated on Construction Documents and as determined by the coordination study.
9. Permanently attached manual operating handle (maximum height 5’6” AFF inclusive of housekeeping pad).
10. Phase barriers full length of blades.
11. 40KA (RMS Symmetrical) fault close rating.
12. 25KA short time rating.
13. Shatter-resistant view window (maximum height 5’6” AFF) (including Housekeeping Pad).
15. Copper bussed connection to transformer terminals.
16. Plated copper bussing.
17. Designed for Seismic Zone 4.
18. Mechanically interlocked hinged door with cylinder locks and wind latch.
19. Plated copper ground bus bonded to steel frame with cable lug termination.
20. NEMA class porcelain insulators for bus supports and porcelain inserts at bus penetrations.
22. Electrostatically applied polyester power paint finish (min. 2 mil) thickness). Color shall be light gray (ANSI 70).
23. Operating mechanism shall have mechanical heavy-duty steel linkage. Chain or plastic strap is not acceptable.
24. Copper bus connection to transformer except that final connection shall be with copper braided flexible straps.
25. Space and mounting brackets for 15 KV cable porcelain type slip-on terminations.
26. Distribution class porcelain surge arrestors (metal oxide), 12 kV rated, connected to incoming 12 KV primary terminals. Locate at bottom of enclosure.
27. Warning signs on front and rear stating “Danger High Voltage – Keep out”.

2.4 TRANSFORMER SECTION

A. A single ventilated dual primary cast-coil transformer shall be provided integral to the Unit Substations. Ratings and descriptions for each Substation shall be as follows:

1. 12000V, 3Ø, 3W (Delta) primary voltage.
2. 3Ø, 4W (Wye), secondary voltage as noted on drawings.
3. KVA rating as indicated on drawings.
4. 60 cycle operation.
5. 80°C rise above a 40°C ambient temperature.
6. Copper windings.
7. Separate high and low voltage coils, coaxially mounted.
8. Fully rated taps in high voltage winding. Two (2) taps 2-1/2%AN, two (2) 2-1/2% BN (rated primary voltage) with external pad-lockable tap changing mechanism for de-energized operation only.
9. Epoxy casted in a mold for both primary and secondary.
10. Throat or transition section to secondary.
11. Primary bushings enclosed in flanged transition section and coordinated with busing from primary switch or incoming cables.
12. 95KV BIL rated at primary termination.
13. Provide grounding pad.
14. Impedance shall be 5.75% (±5%) or ANSI standard.
15. Designed for Seismic Zone 4.
16. Indoor type enclosure.
17. Porcelain barriers between sections and porcelain insulators shall be provided in each substation.
18. Electro statically applied polyester power paint finish (min. 2 mil) thickness). Color shall be light gray (ANSI 70).
19. Air cooled transformer complete with winding temperature sensing and alarm system.
20. Distribution class porcelain surge arrestors (metal oxide), 12 kV rated, connected to incoming 12 KV primary terminals.

B. All materials and equipment shall be new, modern in design and shall not have been in prior service except as required by factory tests.

C. All units shall be designed, manufactured and tested in accordance with ANSI C57.12.01, ANSI C57.12.91, and NEMA TR-1.

D. Coils shall be cylindrically wound, disc development with alternate discs wound inside out, outside in, etc, successively, without air ducts. Barrel wound coils are not acceptable. The conductor shall be copper wire properly sized, pre-insulated with temperature, 220°C, insulation before winding and casting and supported for line and load voltage and currents to be encountered in normal operation, including short circuits. All the windings shall be complete impregnated, cast in epoxy resin rated at 185°C in a mold, using a mixing and vacuum casting process, oven cured to insure the absence of voids. Casting epoxy shall be filled as well as fiberglass reinforced and shall be self-extinguishing. The filler shall effect pure epoxy to increase strength, arc resistance, thermal conductivity, and adhesion to conductor and change the coefficient of expansion to be closer to that of the conductor material.

E. The core shall consist of thin, individually insulated sheets of high permeability, grain-oriented, non-aging silicone steel miter-corner-cut without burrs and hand stacked into a cruciform arrangement of different widths of laminations, to provide a cross-section most nearly resembling the circular cross-section inside the low voltage coil. Stacking shall include staggered gaps. Flux density shall be kept well below saturation.

F. The assembled core shall be braced with heavy (minimum 0.25 inch thick) formed steel angles and channels with stiffeners welded on where required to apply uniform clamping forces across the entire width, top and bottom, and with steel straps running top to bottom down each core leg, front and back, inside each coil welded top and bottom to permit lifting of the entire core and coil assembly from top framing members. The core shall be protected from corrosion with a 185°C or higher rated rust resisting coating.

G. The core and coil assembly shall consist of separate high and low voltage coils for each phase, mounted coaxially with high/low air space between coil sized to accommodate the rated voltage potentials. Each coil shall be supported on epoxy blocks top and bottom with resilient pads to retain the coils while permitting them to expand thermally under loading. Coils shall be mounted and supported in place on the transformer core and the assembly shall be designed and manufactured to withstand without damage the short circuit testing per current ANSI standards.

H. All bussing shall be rated to withstand maximum short circuit stresses when connected to a supply system having a fault capacity of 750MVA symmetrical at rated voltage. The low voltage bus shall be high conductivity copper with welded connections to coil windings. Connection surfaces shall be silver-plated copper. Bus sizes shall be adequate for maximum current during fan cooled conditions at rated voltage and temperature.
I. The high voltage bus shall be high conductivity copper with porcelain insulators (phenolics or epoxies are not acceptable). Connection surfaces shall be silver plated copper. Taps shall have flexible insulated copper cables; solid copper links or jumpers, penetration through sheet metal into primary section shall have porcelain isolators.

J. Ground bus shall be ¼ x 2 inch copper with appropriate terminal connection locations and shall extend the full length of the enclosure.

K. Enclosure shall allow for ventilation, special vents such as double barber-colman grills or equal.

L. Provide solid state transformer winding temperature sensing and alarm system. Each phase coil of the transformer shall be equipped with high accuracy thermistor type temperature sensors to continuously monitor the internal coil temperature.

1. The control module shall be “draw-out” design permitting inspection of the control unit without exposure to high voltages.
2. The system control module shall have a membrane front panel with switches to provide system tests and alarm silencing. Function indicators shall be LED bars, green for “Power ON”, red for “High Temperature”.
3. A sonic alarm shall be provided for “High Temperature”. An alarm silence switch shall silence the sonic alarm, but allow the red LED bar to remain on until the temperature decreases to normal.
4. The system control module shall provide a digital read-out of transformer coil temperature and numeric coil identification.

M. The enclosure shall be constructed of sheet steel with minimum thickness of 12 gauge. Side and end panels shall have formed edges for rigidity and bolt holes for assembly. The roof panel shall have flanged edges, welded corners and be sloped to cause water to run off. All steel panels shall be degreased, steam cleaned phosphatized and painted with epoxy based paint.

N. The base shall be rigid structural steel frame capable of supporting the enclosure and the core-and-coil assembly. It shall be welded structure of angles and channel. Construction shall include provisions for jacking and skidding or rolling in both directions. Two ground pads constructed of copper, each with two tapped holes for attaching ground leads shall be provided in diagonally opposite corners.

2.5 SECONDARY SECTION

A. A secondary distribution switchboard including secondary main circuit breaker and distribution devices shall be provided integral to the secondary unit Substation.

B. Ratings and descriptions shall be as follows:

1. Floor standing, 90” maximum height.
2. Sheet metal enclosure.
3. Dead-front, dead-rear
4. Over-current devices, relays, and instrumentation shall be provided.
5. Main over-current devices shall be insulated-case, individually mounted, microprocessor controlled circuit breakers. Circuit breakers 1000A frame and above shall be draw-out type with adjustable long, short, instantaneous and ground (LSIG) functions.
6. Distribution over-current devices shall be molded case circuit breakers, group mounted devices. Circuit breakers 400A frame and above shall have adjustable long, short, instantaneous and ground (LSIG) functions.
7. Copper bus. (Full height bus in each section).
8. Minimum 65,000 amperes interrupting capacity (RMS Symmetrical) unless otherwise noted.
9. Rated voltage per single line diagrams.
10. Enclosure: NEMA 1 for indoor and NEMA 3R walk-in type for outdoor (unless otherwise noted).
11. Copper ground bus extends for full length of switchboard mounted and bonded to each section with provision for feeder ground terminations.
12. Permanently mounted engraved phenolic nameplates, black face with white lettering minimum 3/8” letter on 1-1/4”x2-1/2” plate.
14. Provision for padlocking handles on all over-current devices.
15. Electro statically applied polyester power paint finish.
16. Top or bottom feeder entry as indicated on plans.
17. Non-tapered cross bus.
18. Fully rated, non-tapered neutral bus.
19. Removable neutral disconnect link.
20. Completely factory wired and assembled.
21. Meters shall be mounted minimum 5’-6” above finished floor.
22. Electro statically applied polyester power paint finish (min. 2 mil) thickness). Color shall be light gray (ANSI 70).

C. Switchboard shall include all devices shown on Construction documents and as specified herein. Over-current devices, relays, surge arrestors, capacitors, instrumentation, control wiring, terminal blocks and pressure type line terminals (suitable for either copper or aluminum conductors) shall be provided as required. Provide terminal blocks with suitable numbering strips for control wiring leaving switchboard. Maximum height of circuit breakers shall be 5’-6” AFF inclusive of house keeping pad.

D. Provide full length copper cross bussing. Locate cross-bus at rear of vertical bus midway between top and bottom of structure. Cross bussing at top or bottom of sections is not acceptable. Rating of vertical bus shall match cross-bussing rating.

E. Symmetrical short circuit rating of switchboard shall be stamped on manufacturer’s nameplate. Series rated devices or systems are not acceptable.

F. Rodent-proof ventilation as required to maintain allowable temperature rise at rated capacity.

G. Zero sequence type ground fault protectors shall be provided. Relay, field adjustable with solid-state circuitry to shunt trip breakers. Monitor panel on face of switchboard with READY pilot light, ground fault indicator, reset button, provisions for field for field test without service interruption and alarm contact.

H. Provide Digital metering and monitoring as indicated. Digital meter shall be Square D PM620, Cutler Hammer IQ200, General Electric or equal. Meter shall be factory installed in the switchboard.

2.06 ACCESSORIES

A. Equipment shall include:

1. Diagram instruction plate.
3. Removable case panel for access to high-voltage strap-type connector taps for de-energized tap changing.
PART 3 – EXECUTION

3.1 FIELD QUALITY CONTROL

A. Inspect installation for dimensions, physical damage, proper alignment, anchorage, grounding, and completeness.

B. Check continuity of all circuits.

C. Check polarity and phasing of bussing.

D. Inspect bus bar spacing, insulators, wiring and devices for compliance with ANSI, NEC, and UL standards.

E. Check tightness of all bolted connections.

F. Check nameplates and identification.

G. The Contractor shall protect all equipment during delivery, storage, installations and at all times during construction. Substations or their components shall not be exposed to weather, moisture, dust, dirt, debris or damage during construction (unless specifically rated for conditions).

3.2 INSTALLATION

A. Install Secondary Unit Substation in accordance with manufacturer’s written instructions, NEMA standards, CEC, and IEEE requirements.

B. Provide clean, level surface for installation with suitable structural strength. Verify compliance with Seismic Zone 4 requirements.

C. Coordinate fuse type, fuse size, circuit breaker ratings, circuit breaker settings with available fault current, coordination study, and short circuit study.

D. Permanently install all nameplates and circuit identification.

E. Provide ground continuity through means of driven ground rods, bonding to building steel, or bonding to building grounding electrode.

F. Provide adequate space for future expansion where designated.

G. Install device handles to a height no greater than allowed by CEC (U.O.N.).

H. Provide blank panels to ensure dead-front, dead-rear installation.

I. Substation shall be plumb and square to building structure. Provide CEC and UBC required clearance on all sides of substation.

J. Coordinate installation and schedule with all other trades and University’s Representative.

K. The contractor shall coordinate all components including their arrangement electrically and mechanically.
L. The Contractor shall coordinate conduit entrances including method of entrance and connections.

M. The Contractor shall coordinate with all other trades necessary to provide a complete, proper installation. Grades, piping, structure, ducting, etc. shall be carefully reviewed by the contractor prior to installation.

3.3 ANCHOR REQUIREMENTS

A. All equipment bases shall be fabricated with an adequate number of anchor bolt holes designed to put the base in direct contact shear and tension with the concrete pad at all anchor bolt locations.

B. Anchorage shall be designed to utilize simple ASTM A307 anchor bolts with heads imbedded 4 inches in concrete with an ultimate compressive strength of 3000 psi.

3.4 CABLE CONNECTIONS

A. Cable termination and connection shall cause no stress at connection to transformer.

B. Terminations of insulated power cables shall be protected at full rated voltage against deterioration of coverings, and moisture by use of terminating devices and materials.

C. Terminations shall be made using materials and methods specified in specifications section for medium voltage cables.

3.5 GROUNDING

A. Grounding shall be in accordance with ANSI C2. All ground wires shall be copper. Refer to section “Grounding and Bonding”.

3.6 NAMEPLATES

A. Provide nameplates as specified in section “Electrical Identification”.

3.7 FIELD TESTS

A. Field tests shall be done by an independent testing agency.

B. Refer to section for “Acceptance Testing” for additional requirements. All testing shall comply with ANSI C57.12.91.

C. In addition to the field tests, contractor shall perform the following after energizing the transformer:

1. Check the phase rotation on the secondary of the new transformer.
2. Measure the secondary voltage of the new transformer and reset the primary taps if necessary.
3. Furnish test reports to College’s Representative within 10 days after completion of testing.

3.8 INSTRUCTION MANUAL
A. The manufacturer shall submit within one week prior to shipment of the transformer complete installation, operation and maintenance manuals suitable for the specific items to be supplied, including such information as:

1. Interconnection diagrams.
2. Drawings.
3. Instruction describing procedures for item which are to be shipped disassembled but which are to be assembled when sited.
4. Special rigging instructions.
5. Accessories.
6. Instructions for tap changing.
7. Enclosure assembly and disassembly.
8. FAC temperature reading and setting procedures.
9. Other information designed to assist in proper operation and periodic maintenance of the equipment being supplied. Key interlocking provisions shall be identified and serial numbers supplied.
10. Table of contents and tab separators.
11. “As manufactured” drawings and wiring diagrams.

B. A minimum of six (6) manuals shall be delivered to the College’s Representative.

3.9 START-UP AND TRAINING

A. Contractor shall engage the services of manufacturer’s authorized trained field service engineer for startup.

B. Check all circuits for continuity and safety prior to energization. Notify College’s Representative prior to energization such that adequate preparation is made for power.

C. Train College’s Representative (or appropriate staff) for a period no less than four hours in regard to start-up, operation, and maintenance of the substation and its components.

3.10 CLEANING AND REPAIR

A. Clean substation interior and exterior of grease, dirt, debris, dust, excess paint, plaster, spackle, unused wire, etc.

B. Repair and paint enclosure as necessary to return to the enclosure to the original factory condition.

C. Damage to electrical components shall be repaired in the factory.

END OF SECTION 16322
SECTION 16402 – UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies PVC conduit, plastic utilities duct, precast manholes, warning tape and raceway tags.

1.2 RELATED SECTIONS

A. Section 16010 - Electrical General Requirements
B. Section 16050 - Basic Materials and Methods
C. Section 16122 - Medium Voltage Cable
D. Section 16170 - Grounding and Bonding
E. Section 16195 - Electrical Identification

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. American Association of State Highway and Transportation Officials (AASHTO)
   1. AASHTO HB14 Highway Bridges
   2. AASHTO M198 Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets

B. American Society for Testing and Materials (ASTM)
   1. ASTM C 478 Precast Reinforced Concrete Manhole Sections

C. National Electrical Manufacturers Association (NEMA):
   1. TC3-90 PVC Fittings for Use with Rigid PVC Conduit and Tubing
   2. TC6-90 PVC and ABS Plastic Utilities Duct for Underground Installation
   3. TC9-90 Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
   4. TC8-90 Extra Strength PVC Plastic Utilities Duct for Underground Installation

D. National Fire Protection Association (NFPA) Publication:
   1. 70-99 National Electrical Code (NEC)

E. State of California Codes of Regulations (CCR) Publication:
   1. Title 24, Part 3, CCR, 2001 California Electrical Code
F. State of California Public Utilities Commission (Cal. P.U.C.) Publication:

G. Underwriters Laboratories (UL) Publications:
   1. 514B Fittings for Conduit and Outlet Boxes
   2. 651 Schedule 40 and 80 Rigid PVC Conduit
   3. 651A Type EB and A Rigid PVC Conduit and HDPE Conduit

1.4 GENERAL

A. Raceway sizes are minimum allowable based upon NEC requirements when using the cable insulation indicated. Contractor may increase conduit size at contractor's discretion and at no additional cost to Owner to facilitate cable pulling.

1.5 SUBMITTALS

A. Submit six (6) copies.

B. Furnish descriptive literature for the following equipment or devices supplied under this section:

   1. PVC schedule 40 conduit
   2. Precast manholes (all types)
   3. Raceway tags
   4. Duct spacers
   5. Warning tape

C. Shop drawings: Provide for accessory locations for precast manholes.

1.6 PROJECT CONDITIONS

A. The drawings are diagrammatic and shall not be scaled for exact locations. The location of existing underground utilities are based on Owner record drawings and casual field observations. The Contractor shall use reasonable care in excavating for the installation of new underground ducts and shall be responsible for damage to existing underground utilities. Field conditions and non-interference with other utilities and trades, shall determine exact locations of new underground electrical ducts. Hand dig areas close to existing utilities, to avoid damage.

B. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

1.7 PROJECT RECORD DOCUMENTS

A. Accurately record actual locations of exact routing of ductbank indicating plan location and depths every 50 linear feet. Measure conduit locations from permanently fixed readily discernible landmarks such as building corners, columns, manhole centerline, etc.

B. Accurately record actual locations of each manhole.
PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT: All materials and equipment shall be new and of high quality to give long life and reliable operation. Materials and equipment shall conform to the respective specifications and standards and to the specifications herein.

2.2 PVC SCHEDULE 40 CONDUIT
   A. Use rigid PVC Schedule 40 conduit, UL listed for concrete-encased, underground direct burial, concealed and direct sunlight exposed use, and UL listed and marked for use with conductors having 90 degrees C insulation. Use conduits meeting the requirements of NEMA TC 2, UL, NEC and ASTM specified tests for intended use. Use only conduit with a factory formed bell on one end. Conduit that requires the use of couplings for straight runs will not be acceptable. Minimum size conduit shall be one (1) inch.

2.3 RACEWAY FITTINGS
   A. Fittings for PVC Conduit: Use UL listed PVC couplings, bushings, elbows, nipples, and other fittings manufactured in accordance with NEMA TC-3, UL, NEC and ASTM specified tests for intended use. Fittings shall be of same manufacturer as the conduit.
   B. Use large radius sweeps & bends for conduits carrying high voltage cables and telecommunication cables unless otherwise noted on the drawings.

2.4 RACEWAY TAGS
   A. Provide permanent markers with raceway designations engraved onto the plastic laminated tag. Tags relying on adhesives or taped-on markers are not acceptable. Attach tags to raceways with nylon ties.

2.5 WARNING TAPE
   A. Provide as specified in Section 16195, "Electrical Identification".

2.6 MOISTURE SEALING MATERIAL
   A. Provide a two-part urethane foam sealant which when mixed will expand approximately 15 times in volume to form a dense, strong tough foam unit with a density of 3 to 4 pounds per cubic foot. Sealant shall reach 60% full strength in 8 to 10 minutes after application.

PART 3 - EXECUTION

3.1 INSTALLATION: Underground cable installation shall conform to NFPA 70, CAL. P.U.C. G.O.128, CCR Title 24 Part 3, and all other state codes.
   A. Provide raceway systems meeting or exceeding the requirements of the NEC.
3.2 PROTECTION DURING CONSTRUCTION

A. In addition to the requirements of the General Conditions, Division 1 General Requirements and Section 16010, Electrical General Requirements, prior to installation, store all products specified in this section in a dry location. Following installation, protect products from the effects of moisture, corrosion, and physical damage during construction. Keep openings in conduit and tubing capped with manufactured seals during construction.

3.3 REQUIRED RACEWAY TYPE FOR LOCATION AND INSTALLATION METHOD

A. Concrete Encased Raceways
   1. PVC Schedule 40 Conduit

B. Direct Buried Raceways
   1. PVC Schedule 40 Conduit

3.4 GENERAL INSTALLATION REQUIREMENTS FOR RACEWAYS

A. Location and Routing
   1. Locate raceways at least 12 inches away from parallel runs of heated piping or other utility systems.
   2. In outdoor, underground, or wet locations, use watertight couplings and connections in raceways. Install and equip boxes and fittings so as to prevent water from entering the raceway.
   3. Do not notch or penetrate structural members for passage of raceways except with prior written approval of the Owner.
   4. Except at raceway crossings, separate raceways in slabs not less than six times the raceway outside diameter.
   5. Raceways installed under slabs shall be concrete encased and lie completely under the slab with no part of the horizontal run of the raceway embedded within the concrete slab. The top of the concrete envelope shall be directly under the floor slab.
   6. Install raceways so that they emerge at right angles to the surface and have none of the curved portion of the bend exposed. Provide support during pouring of concrete to ensure that raceways remain in position. Provide galvanized rigid steel elbows where conduit emerges from slab or concrete.
   7. Cut raceways at right angles.
   8. Installation of raceway system shall be coordinated with other disciplines to assure maximum accessibility to all systems.

B. Bends:
   1. Make changes in direction of runs with symmetrical bends or cast metal fittings. Make bends and offsets of the longest practical radius.
   2. Use field manufactured bends where possible. Avoid factory-made bends and offsets unless necessary.
   3. Make bends in parallel on banked runs of raceways from the same center or centerline so that bends are parallel and of neat appearance. Make field bends in parallel or banked raceways if there is a change in the plane of the run and the raceways are of the same size. Make field bends with an acceptable conduit bending machine per manufacturer's recommendations.
4. Use acceptable heating methods for forming bends in PVC conduit as recommended by the manufacturer.
5. The ID of conduits shall not be reduced when making field bends.

C. Penetrations: Where an exterior raceway enters a structure through a concrete roof or a membrane waterproofed wall or floor, provide an acceptable, malleable iron, watertight, entrance sealing device. When there is no raceway concrete encasement specified or indicated, provide such a device having a gland type sealing assembly at each end with pressure bushings which may be tightened at any time. When there is raceway concrete encasement specified or indicated, provide such a device with a gland type sealing assembly on the accessible side. Securely anchor all such devices into the masonry construction with one or more integral flanges. Secure membrane waterproofing to such devices in a permanently watertight manner. Seal raceway with moisture sealing material after pulling and terminating all conductors.

3.5 INSTALLATION REQUIREMENTS FOR UNDERGROUND DIRECT BURIAL AND CONCRETE-ENCASED RACEWAYS

A. General

1. Coordinate installation of underground raceways with other outside and building construction work. Maintain existing outside utilities in operation.
2. Remove entirely and properly reinstall all raceway installations not in compliance with these requirements.
3. Provide a minimum cover of 3 feet over low voltage over high voltage underground raceways unless otherwise indicated.
4. Do not backfill underground direct burial and concrete-encased raceways until they have been inspected by the Owner’s representative.
5. All underground conduits and duct bank containing high voltage feeders (above 600 volts) shall be encased in red concrete. Concrete shall be pre-mixed at the factory using 1-1/2 pounds of red ochre dye in one sack of cement. Sprinkling red oxide is not acceptable. Concrete shall be minimum 2500 psi.
6. Warning Tapes: Provide a plastic warning tape in the backfill over the ductline and approximately 12 inches below grade. Tape shall run continuously along the entire length of the underground utility lines. Tape shall be polyethylene plastic manufactured specifically for warning and identification of all buried utility lines. Tape shall be of the type provided in rolls, 6-inches minimum width, color coded for electric lines (red) and for communication lines (orange), with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape. Warning identification shall be “CAUTION – BURIED ELECTRIC (or COMMUNICATION) LINES BELOW”, or similar wording. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.

B. Separation and Support:

1. Separate parallel runs of two or more raceways in a single trench with preformed, nonmetallic spacers designed for the purpose. Install spacers at intervals not greater than that specified in the NEC for support of the type raceways used, and in no case greater than 10 feet.
2. Support raceways installed in fill areas to prevent accidental bending until backfilling is complete. Tie raceways to supports, and raceways and supports to the ground, so that raceways will not be displaced when concrete encasement or earth backfill is placed.

C. Arrangement and Routing:
1. Arrange multiple conduit runs substantially in accordance with any details shown on the Drawings. Locate underground conduits where indicated on the Drawings and graded to the elevations shown.

2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where raceway runs cannot be installed substantially as shown because of conditions not discoverable prior to digging of trenches, refer the condition to the Owner for instructions before further work is done.

3. Where other utility piping systems are encountered, maintain a 12-inch minimum vertical separation between raceways and other systems at crossings. Maintain a 12-inch minimum separation between raceways over couplings in other piping systems. Refer conflicts with these requirements to the Owner for instructions before further work is done.

4. In multiple conduit runs, stagger raceway coupling locations so that couplings in adjacent raceways are not in the same transverse line.

D. Direct Earth Burial Conduit Zone Backfill Installation:

1. Backfill material for the conduit zone of direct burial conduit trenches may be selected from the excavated material if it is free from roots, foreign material, and oversized particles. Use material with 3/4-inch maximum particle size and suitable gradation for 95% compaction. Remove or add material as necessary to meet these requirements. Place and compact materials in continuous layers not exceeding 8 inches compacted depth.

2. Imported 3/4-inch minus gravel or sand may be used in lieu of material from the excavation.

3. After conduits have been properly installed, backfill the trench with specified material placed around the conduits. Carefully tamp around and over the conduits with hand tampers. Final, tamped conduit cover shall be 6 inches minimum.

E. Concrete Encasement:

1. Maintain a grade of at least 4 inches per 100 feet, either from one manhole or pull box to the next, or from a high point between them, depending on the surface contour.

2. Hold conduits for concrete-encased raceways securely in place by acceptable window type spacer supports. Where, in the opinion of the Owner Representative, ground conditions are such as to require concrete forms, install forms constructed of materials and in a manner acceptable to the Owner’s Representative. No variations greater than 1/2 inch in 50 feet will be permitted from a straight line.

3. Envelopes may be poured directly against the sides of trenches if the cut is clean, even, and free of loose material. Remove loose material from trenches before and during pouring of concrete to ensure sound envelopes. Carefully spade slurry during pouring to eliminate all voids under and between raceways and honeycombing of the exterior surface.

4. Do not use power-driven tampers or agitators unless they are specifically designed for the application, in order to ensure that the watertight integrity of the raceways is maintained.

3.6 MANHOLES AND CABLE VAULTS

A. Install manholes and handholes where shown on the drawings. Provide excavation, shoring, bracing, backfilling, grading, etc., in accordance with requirements specified elsewhere in these contract documents.

B. Do not install manholes or handholes until final conduit grading, including field changes necessitated by underground interferences, has been determined. Set frames to final grades as required.

C. Make installation so that raceways enter manholes or handholes at nearly right angles and as near as possible to one end of a wall, unless otherwise indicated.
D. Prior to installation of manholes and handholes, the surface shall be leveled and compacted to a minimum 90% compaction. Provide a 12” bed depth of 1” size rock under the entire base.

E. In existing manholes, maintain a minimum separation of 12 inches from all low voltage wiring. Low voltage wiring shall not be permitted in new manholes except where noted on drawings.

F. Core drill or saw cut conduit entrances into existing manholes. Provide a bell end in the manhole panel. Completely seal around the conduit penetrations.

G. Install additional cable racks in existing manholes as required for the cables being installed. Set racks and inserts on not greater than 36 inch centers around entire perimeter of the manhole. Provide a sufficient number of arms for new and existing rack assemblies to accommodate the cable installation.

H. Penetration for conduit entrances in existing manholes and handholes shall be made by core drilling. Contractor shall use extreme care in working inside existing manholes which contain energized cables.

3.7 PREPARATION FOR PULLING IN CONDUCTORS

A. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.

B. Immediately after installation, plug or cap all raceway ends with water-tight and dust-tight seals until the time for pulling in conductors.

C. For all new concrete-encased raceways, after the concrete envelope has set, pull a mandrel of a diameter approximately 1/4 inch less than the raceway inside diameter, through each raceway. Then pull a bristle brush through each raceway to remove debris.

D. For existing underground raceways, pull a mandrel of a diameter approximately 1/4 inch less than the raceway inside diameter, through each raceway. Then pull a bristle brush through each raceway to remove debris.

3.8 EMPTY RACEWAYS

A. Certain raceways will have no conductors pulled in as part of the Contract. Identify with tags at each end and at any intermediate pull point the origin and destination of each such empty raceway. Where a raceway has been identified with a name (number) in the Raceway Schedule, use that name on the tag in lieu of origin and destination. Provide a removable permanent cap over each end of each empty raceway. Provide a 1/8" polypropylene pull cord in each empty raceway. Pull cord in telephone/data service conduits (4” and larger) shall 3/16” size.

B. Rod, clean and provide pull rope in all existing ducts to be used for conductor paths under this Contract.

END OF SECTION 16402
SECTION 16429 – LOW-VOLTAGE DISTRIBUTION SWITCHBOARDS

PART 1 - GENERAL

1.1 SCOPE

A. The Contractor shall furnish and install, where indicated, a free-standing, dead-front type low-voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the contract drawings.

1.2 RELATED SECTIONS

A. Section 16195 - Electrical Identification

1.3 REFERENCES

A. The low-voltage distribution switchboards and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards:

1. NEMA PB-2
2. UL Standard 891.

1.4 SUBMITTALS -- FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view elevation
3. Floor plan
4. Top view
5. Single line
6. Schematic diagram
7. Nameplate schedule
8. Component list
9. Conduit entry/exit locations
10. Assembly ratings including:
   a. Short-circuit rating
   b. Voltage
   c. Continuous current
11. Major component ratings including:
   a. Voltage
   b. Continuous current
   c. Interrupting ratings
12. Cable terminal sizes.
B. Where applicable, the following additional information shall be submitted to the Engineer:

1. Busway connection
2. Connection details between close-coupled assemblies
3. Composite floor plan of close-coupled assemblies
4. Key interlock scheme drawing and sequence of operations.

C. Submit ten (10) copies of the above information.

1.5 SUBMITTALS -- FOR INFORMATION

A. When requested by the Engineer, the following product information shall be submitted:

1. Descriptive bulletins
2. Product sheets.

1.6 SUBMITTALS -- FOR CLOSEOUT

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in section 1.04
2. Wiring diagrams
3. Certified production test reports
4. Installation information
5. Seismic certification and equipment anchorage details.

B. Submit ten (10) copies of the above information.

1.7 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the circuit protective devices within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The switchboard shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchboard manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 1.8g, and a ZPA of 0.45g. The tests shall fully envelope this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1.8 REGULATORY REQUIREMENTS

A. The low-voltage switchboard shall be UL labeled.
1.9 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Ten (10) copies of the equipment operation and maintenance manuals shall be provided.

B. Operation and maintenance manuals shall include the following information:
   1. Instruction books and/or leaflets
   2. Recommended renewal parts list
   3. Drawings and information required by section 1.06.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. Cutler Hammer

C. General Electric

D. Siemens

2.2 RATINGS

A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current 65,000 amperes symmetrical at rated voltage.

B. Voltage rating to be as indicated on the drawings.

2.3 CONSTRUCTION

A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

B. All sections of the switchboard shall be rear aligned with depth as shown on the drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front accessible enabling switchboard to be mounted against a wall.

C. The assembly shall be provided with adequate lifting means.

D. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.
2.4 BUS

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.

C. A copper ground bus (minimum 1/4 x 2 inch), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

2.5 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.

C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminals blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

2.6 MOLDED CASE PROTECTIVE DEVICES

A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics and shall have ground fault protection where indicated or as required by NEC.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make/quickbreak over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy, and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

D. Where indicated circuit breakers shall be UL listed for series application.

E. Where indicated circuit breakers shall be current limiting.
F. Circuit breakers 400 ampere frame and below shall be thermal-magnetic trip unit type with inverse time-current characteristics.

G. Circuit breakers 600 ampere through 1200-ampere frame shall be microprocessor-based with RMS sensing trip units.

H. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.

2.7 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.

B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.8 FINISH

A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground.

B. The manufacturer shall provide three (3) certified copies of factory test reports.
3.3 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's instructions, contract drawings and National Electrical Code.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to floor. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.4 FIELD ADJUSTMENTS

A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.

B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with an approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

END OF SECTION 16429
SECTION 16460 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General purpose dry type two winding transformers, including all labor, materials, appliances, tools, equipment necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein.

1.2 RELATED SECTIONS:

A. Section 16010, Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

B. Section 16030 - Acceptance Testing.

C. Section 16170 - Grounding and Bonding.

D. Section 16195 - Electrical Identification.

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute, Inc. (ANSI) Publications:

1. C57.12.01-79 General Requirements for Dry-Type Distribution and Power Transformers
2. C57.12.91-79 Test Code for Dry-Type Distribution and Power Transformers
3. C57.94-82 Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers

B. National Electrical Contractors Association (NECA) Publication:

1. Standard of Installation.

C. National Electrical Manufacturer's Association (NEMA) Publications:

1. ST 20-72 (R78) Dry Type Transformers for General Applications.
2. TR 1-80 (R83) Transformers, Regulators and Reactors

D. National Fire Protection Association (NFPA) Publication:

1. 70-99 National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submit under provisions of Section 01340.
B. Manufacturer’s Data: Provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, rated winding temperature rise, nameplate legends and anchor calculations.

C. Test Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this Section shall have a minimum fifteen (15) years documented experience, and ISO 9002 Certification.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with NECA Standard of Installation.

B. Maintain one copy of each document on site.

C. The manufacturer shall have a minimum of fifteen years documented experience in the manufacture of similar units.

D. Manufacturer shall carry ISO 9002 certification.

E. Manufacturer shall carry spare parts for the switchgear for a minimum period of ten (10) years from the date of installation and provide a written statement with confirmation of such.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Furnish products listed and classified by UL as suitable for purpose specified and shown.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store, protect, and handle products to site.

B. Deliver transformers individually wrapped for protection and mounted on shipping skids.

C. Accept transformers on site. Inspect for damage.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.
PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. All materials and equipment shall be new and of high quality to give long life and reliable operation.

B. All equipment shall be modern in design and shall not have been in prior service except as required by factory tests.

2.2 TWO-WINDING TRANSFORMERS

A. Acceptable manufacturers are Square D, General Electric, Cutler Hammer or equal.

B. Description: NEMA ST 20, ANSI C57.12.01, 60 Hertz, factory-assembled, distribution, air cooled, dry type transformers, with copper windings and ratings as indicated.

C. Transformer shall have 220°C insulation with a winding temperature rise not exceeding 115°C under full load in a maximum ambient of 40°C.

D. Case temperature: Do not exceed 35 degrees C rise above ambient at warmest point.

E. Winding Taps: NEMA ST 20. Equip with NEMA standard taps. If taps are not standard, equip transformer with two 2-1/2% FCAN and two 2-1/2% FCBN.

F. Sound Levels: NEMA TR 1. Maximum sound levels shall be an average of 3 dB lower than NEMA TR 1 standard sound levels for the transformer size indicated.

G. Basic Impulse Level: 10 kV for transformers less than 300 kVA, 30 KV for transformers 300 kVA and larger.

H. Minimum impedances, unless otherwise indicated, shall be as follows:

1. 75 kVA and smaller: 3.0%
2. Larger than 75 kVA: 4.5%

I. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap. Where neutral connection is indicated, attach to bolt and lug inside enclosure and extend bolt through enclosure to permit external ground connection.

J. Mounting: Suitable for wall, trapeze or floor mounting as indicated.

K. Coil Conductors: Continuous cooper windings with terminations brazed or welded. Brace and locate windings, terminals, and connections for maximum short circuit stresses to prevent accidental grounding of windings and connections.

L. Enclosure: NEMA ST 20; Type 1 unless otherwise noted. Provide lifting eyes or brackets. Construct enclosures of heavy gage sheet steel, primed inside and out with a zinc chromate or iron oxide rust-inhibiting primer. Finish with manufacturer's standard color enamel. Overall dimensions shall not exceed the limits indicated or the space available.

M. Isolate core and coil from enclosure using vibration-dampeners.
N. Nameplates:
   1. Conspicuously display on each transformer enclosure a metal nameplate with stamped or engraved markings showing: connection, including taps; kVA; phases; frequency; primary and secondary voltages; percent R, X and Z; temperature rise; insulation class; BIL rating; no-load and full-load losses; and sound level rating.
   2. Provide laminated plastic nameplate as specified in Section 16195, identifying transformer designation in 1/2" high letters.

2.3 SOURCE QUALITY CONTROL
   A. Provide testing of transformers under provisions of Section 01400.
   B. Provide production testing of each unit in accordance with NEMA ST 20 and ANSI C57.12.91. The following tests shall be performed at the factory:
      1. Applied voltage test (to each winding and from each winding to ground).
      2. Induced voltage test - 2 times normal voltage.
      3. Ratio, polarity and sound level.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Transformer installation shall conform to NFPA 70, ANSI C57.94, and all other state and local codes, and to requirements specified herein.
   B. Contractor shall make all field verifications necessary to ensure proper installation of all equipment as supplied.
   C. Contractor is responsible for coordinating timely equipment delivery.
   D. Install Products in accordance with manufacturer's instructions.
   E. Set transformer plumb and level.
   F. Make conduit connections to side panel of enclosure.
   G. Provide seismic restraints.

3.2 GROUNDING
   A. Grounding shall be in accordance with ANSI C2. All ground wire shall be copper.
   B. Refer to Section 16170 "Grounding and Bonding".
3.3 NAMEPLATES
   A. Provide as specified in Section 16195, "Electrical Identification."

3.4 FIELD TESTS
   A. Refer to Section 16030, "Acceptance Testing.", for additional requirements. As an exception to
      requirements that may be stated elsewhere in the Contract, the College’s Representative shall be given a
      minimum 14 working days notice prior to each test. All testing shall comply with ANSI C57.12.91.
   B. Field inspection and testing will be performed under provisions of Section 01405.
   C. Check for damage and tight connections prior to energizing transformer.
   D. Measure the secondary voltage of the new transformer and reset the primary taps if necessary.
   E. Test information shall be supplied to the College’s Representative within 10 days after completion of testing.

END OF SECTION 16460
PART 1 - GENERAL

1.1 SCOPE

A. Provide all lighting fixtures as shown, scheduled on the drawings, and for certain fixtures specified in detail herein, Provide complete with all lamps, completely wired, controlled, and securely attached to supports.

B. Where both catalog number and narrative and/or pictorial description are indicated, the requirements of the description shall take precedence and prevail.

C. Contractor shall provide each specified manufacturer with complete information about the fixtures they will supply.

D. Type of fixtures shall be as indicated alphanumerically and as specified.

E. Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:
   1. Fixture performance is equal or improved;
   2. Structural, mechanical, electrical, safety and maintenance characteristics are equal or improved;
   3. Cost to the Owner is unchanged or reduced;
   4. Modifications have been reviewed and approved by the Owner’s Representative in writing.

F. Reflector cones, baffles, louvers, aperture plates, and decorative elements of fixtures shall be packed by the manufacturer separate from the housing (body, stem, etc.) of the fixture.

G. Blemished, damaged or unsatisfactory fixtures shall be replaced in a satisfactory manner.

1.2 RELATED SECTIONS: Examine other sections of Division 16 and ascertain their effect upon, and relationship to the work of this section. Provide the products, and execute the work in this section in accordance with the product and execution requirements, where applicable, as set forth in the other sections of division 16, to provide an interrelated electrical system.

A. Section 16010 - Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

B. Section 16050 - Basic Materials and Methods.

C. Section 16170 - Grounding and Bonding.

D. Section 16195 - Electrical Identification.

1.3 APPLICABLE PUBLICATIONS: The following publications form a part of this specification. The publications are referred to in the text by the basic designation only.

A. American National Standards Institute, Inc. (ANSI) Publications:
1. C78.379 Electric Lamps - Incandescent and High-Intensity Discharge Reflector Lamps - Classification of Beam Patterns.
2. C82.01 Specification for Fluorescent Lamp Ballasts.
3. C82.04 High-Intensity Discharge Lamp Ballast (Multiple Supply Types).

B. American Society for Testing and Materials (ASTM) Publications:
   1. B136-84 Measurements of Stain Resistance

C. National Electrical Manufacturers Association (NEMA) Publications:
   1. WD 6 Wiring Device Configurations.

D. National Fire Protection Association (NFPA) Publication:
   1. 70-99 National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Shop Drawings:
   1. Fixtures: Indicate name of project; building name; fixture type; complete details and/or data of fixtures, including manufacturer's name, catalog numbers for lampholders, ballasts, lightshields, switches; metal gauges; type of wiring; color and texture of finishes; and list of materials.

C. Product Data: Provide dimensions, ratings, and performance data for lighting fixtures electronic ballast. Submit samples of finishes and photometric data from an independent testing laboratory to completely describe fixture performance.

D. Manufacturer's Installation Instructions: Indicate handling and installation methods.

E. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.

1.5 OPERATION AND MAINTENANCE MANUAL

A. Submit operation and maintenance manual for fixtures and ballast under provisions of Section 01700 and 16010.

B. Maintenance Data: Include replacement parts list.

1.6 INSTRUCTION TO OWNER PERSONNEL

A. Provide minimum one half day to instruct Owner personnel in proper operation and maintenance of system. Train Owner personnel in procedures to follow in identifying sources of operational failures or malfunctions.
1.7 PROJECT RECORD DOCUMENTS
   A. Accurately record actual locations of each luminaire.

1.8 QUALIFICATIONS
   A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.9 REGULATORY REQUIREMENTS
   A. Conform to requirements of NFPA 70.
   B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.
   C. Fixtures installed outdoors in areas exposed directly to weather shall be UL listed for wet locations.
   D. Fixtures installed in outdoor protected areas (such as building soffits) and indoors in areas subject to water or extreme humidity shall be UL listed for damp locations.

1.10 GENERAL LIGHTING REQUIREMENTS
   A. Verify ceiling materials employed and coordinate fixtures to mount to the ceiling system used.
   B. Provide support materials of all types necessary to secure lighting fixtures to the building structure.

1.11 FIXTURE EVALUATION
   A. Fixtures offered as equal to the fixtures listed herein shall be equal in the following characteristics:
      1. General appearance and physical dimension.
      2. Finish of materials.
      3. Gage and type of metal used.
      4. Equivalent optical system and lighting efficiency as determined by certified photometric test report.
      5. Equivalent lamp (and ballast) types.
      6. General construction, including door hanging, method of suspension, wire quantities permitted in attached junction boxes and other pertinent construction features.
      7. Type, quality, and thickness of plastic and glass material used for lenses, diffusers or trim.

1.12 FIXTURE SUPPORT AND INSTALLATION
   A. Surface fixtures:
      1. Do not mount fluorescent fixtures directly on combustible material such as fiber acoustical tile unless specifically approved for such use. Provide material required for complying with this code requirement. Install in perfect vertical and horizontal alignment.
2. Support surface mounted fixtures over 4" in width and over 50" in length with a minimum of six fastenings per fixture, two located near each fixture end and two near each fixture center.
3. Locate fastenings for all surface mounted fixtures to provide maximum fixture support and optimum fixture alignment.
4. Fastenings for surface mounted fixtures that are installed on concrete slab or concrete joist construction shall consist of 1/4" minimum size machine screws fastened to concrete inserts that are installed in the slab or joist areas before the concrete is poured.

B. Supplemental support:

1. Include any supplemental support and framing material and fastenings necessary to support lighting fixtures in the locations indicated. Attach this material onto the building structural members. All such materials and installations shall comply with code requirements.
2. Include any foundations required for the support of base mounted lighting fixtures. If the pedestals, poles, or standards supporting such fixtures exceed 10 feet in height, and no foundation details are included on the Contract Documents, provide details of proposed foundations for review by the Owner’s Representative. If required by code, proposed foundation designs must be signed by a registered Structural Engineer.

1.13 DELIVERY, STORAGE AND HANDLING

A. Store, protect, and handle products to site under provisions of Sections 01600 and 16010.
B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
C. Handle in accordance with manufacturer's written instructions.

1.14 WARRANTY

A. Ballasts for fluorescent and high intensity discharge fixtures shall be covered by a two-year warranty against defects in workmanship or material. Warranty shall include in-warranty service program providing for payment of authorized labor charges incurred in replacement of inoperative, in-warranty ballasts.
B. Refer to Section 01700 for information about warranty format.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated. Except where specifically indicated otherwise, provide only new materials having all legally required approvals and/or labels.

2.2 GENERAL MATERIAL REQUIREMENTS

A. Ferrous mounting hardware and accessories shall be finished using either a galvanic or phosphate primer/baked paint process to prevent corrosion and discoloration of plaster.
For weatherproof installation and painted finishes of fixtures and accessories shall be weatherproof enamel using proper primers or galvanized and bonderized epoxy, so that the entire assembly is completely corrosion resistant for the service intended.

1. Hangers shall be conduit with chemically resistant, weatherproof, baked enamel finish.
2. Where aluminum parts come in contact with bronze parts, apply to both surfaces a coating material to prevent corrosion.

C. Fasteners shall be manufactured of non-magnetic stainless steel or anodized aluminum, except in indoor applications where galvanized steel shall be acceptable.

D. Fixtures shall be free of light leaks and shall be designed to provide sufficient ventilation of lamps and ballasts including vent holes where required. Outdoor fixtures shall have wire mesh corrosion resistant screens in the vent holes.

E. All sheet metal work shall be free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal. All intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any deformation after assembly. All sheet metal shall be free of light leaks. All edges shall be finished so there are no sharp edges exposed. All mitres shall be in accurate alignment with abutting intersecting members. Piecing of plates in individual runs in single planes and the use of spliced pieces or filler material to cover defective workmanship shall not be allowed. Sheet metal work shall be properly fabricated so that planes will not deform, i.e. become concave or convex, due to normal expected ambient and operating conditions.

F. Lampholders shall hold lamps securely against normal vibrations and maintenance handling. Provide solid nickel or nickel-and-silver-plated contacts in lampholders for following types of lamps:

1. Metal halide lamps.
2. Lamps in outdoor fixtures.
3. Tungsten-halogen lamps.

G. Wiring channels and lampholder mountings shall be rigid and accurately made.

H. Fluorescent Fixtures:

1. Hot Cathode:
   a. Housing:
      1) No. 20 minimum gauge steel, bonderized or equal rust protected, or No. 16 gauge aluminum rigid construction suitable for continuous row mounting where indicated.
      2) Finish: Baked enamel paint finish unless otherwise specified, color as specified or as selected. For exterior finish, refer to "Exterior Fixture Finishes" below.
   b. Reflector: Minimum 85% reflectance.
   c. Light shields:
      1) Louvers: Continuously bound in channel formed frame, finish and color as specified or as selected. When more than one louver panel occurs in a fixture, submit as a part of the shop drawings the dimensioned layout of individual louver panels and supporting "tee" members.
      2) Louvers shall be of 100% virgin acrylic (except as shown) and shall have matte finish on exterior (facing away from lamps) surface (except as shown).
3) Lenses shall fully eliminate lamp images when viewed from all directions within the 45° to 90° angle from vertical when the ratio of lamp spacing to the distance from lamp underside to top of lens does not exceed 1.50. Within the viewing angle from 0° to 45° the ratio of maximum brightness (under a lamp) to minimum brightness (between lamps) shall not exceed 3 to 1.
4) No cross bars shall be permitted over lightshields.

d. For rapid start lamps on single ballast, provide one (1) grounding lampholder per lamp. Lampholders operating with open circuit voltage in excess of 300 volts shall be safety type and shall open supply circuit when lamp is removed from lampholder.

1) Mount lamps used in rapid start circuits 40 watts and below: within 1/2" of grounded metal as long as the lamp.

e. Fluorescent fixtures shall conform to NEMA Standards, including references to fixture dimensions and temperature ratings.

f. Ballasts shall be high power factor (greater than 90%), approved by UL and certified by ETL. Ballasts shall be certified for voltage and number of lamps specified and equipped with internal thermal overload protectors unless otherwise specified.

1) Ballasts for indoor applications shall be marked "Class P" to show compliance with 1987 NEC Section 410-73(e).
2) Provide two-lamp ballasts where possible including continuous rows of one-lamp fixtures, and one lamp ballasts where the fixture layout does not permit the use of two lamp ballast or as noted on drawing.
3) All ballasts shall operate on voltage as specified and confirmed on the electrical drawings. Ballasts shall operate lamps properly through the following supply voltage ranges.

   a) 277 volt ballasts: 254-289 volts
   b) 120 volt ballasts: 110-125 volts

4) Frequency shall be 60 hertz except as noted.

5) Ballast minimum sound ratings:

   a) 265ma: Class :A" 

6) All 4' long fluorescent ballasts for interior use shall be energy saving, electronic type, dedicated T8 or equal.
7) All fixtures installed in exterior or unheated interior spaces shall be supplied with ballasts which start lamps down to 0°F.

I. High Intensity Discharge Fixtures:

1. Housing, where applicable:

   a. Steel, bonderized or equal rust protected or aluminum, rigid construction. Minimum gauge thickness shall be as follows:

      1) Interior locations: No. 20 gauge steel, No. 16 gauge aluminum.
      2) Exterior locations: No. 18 gauge steel, No. 14 gauge aluminum.

   b. Finish: Baked enamel finish
1) Concealed surfaces: matted black.
2) Visible surfaces: color and texture as specified below for each fixture type or as selected by Owner’s Representative.
3) Exterior fixture finish: Refer to paragraph N., "Exterior Fixture Finishes" below.

c. Lampholder housing: cast aluminum with integral heat radiating fins to assure cool lamp base operation.
d. Fixture housing design shall provide for top and bottom relamping, unless otherwise specified.

2. Reflectors: High purity (not less than 99.0%) aluminum. Specular finish shall be achieved by mechanical-and electro-polishing. Reflector shall be anodized to prevent surface corrosion or deterioration. Minimum reflectance shall be 83%.

3. Provide safety devices for removable fixture elements (cones, reflectors, lenses, and fixture doors, etc.). Safety devices shall support removable elements when not in normal position, and be detachable if necessary. These devices shall not interfere with fixture performance, maintenance, or the seating of any fixture element, and shall not be visible during normal fixture operation.

4. Ballasts: High power factor, UL approved constant wattage auto-transformer type for voltage and lamp specified, 60 hertz.

5. Lighting fixtures recessed in a hung ceiling where the space above the hung ceiling is used as a plenum chamber for either supply or return air for the air conditioning system shall be designed, manufactured and wired to conform to NEC Article 300-22.

2.3 WIRING:

1. Voltage Rating
   a. For voltages 120 volts and above fixture wiring shall be rated for 600 volts minimum.

2. Temperature Rating - Internal to Fixture

3. All wiring shall be code-approved for fixture wiring and shall comply with the following temperature ratings unless fixture design or local codes require higher temperature wire.
   a. Fluorescent
      1) 90°C minimum rating between lampholder(s) and internal ballast.
      2) 90°C minimum rating between ballast and separate junction box or connection with integral wireway.

   b. High Intensity Discharge
      1) 150°C minimum rating between lampholder(s) and separate junction box or connections with ballast components.
      2) 150°C minimum rated between core and coil ballast components and separate junction box.
      3) 90°C minimum rating between encased and potted ballast components and separate junction box.

4. Temperature Rating - External to Fixture
   a. All flexible cord wiring between fixture components or to electrical receptacle and not in wireways shall have a minimum temperature rating of 105°C.
   b. Cord type shall be suitable for application and shall be fitted with proper strain reliefs and watertight entries where required by application.
5. Splices
   a. Splices internal to fixture shall be made within separate splice compartments and shall util-
      ize nylon insulated crimped connections or insulated quick disconnects.
   b. Splices to branch circuit wiring in separate junction boxes shall utilize flame retardant
      thermoplastic caps with fully seated helical metal spring and threaded entry.

6. No internal wiring shall be visible at normal viewing angles, i.e., above 45° from verti-
   cal. Use additional wire clamps if necessary. Anticipate increased visibility if fixtures are
   mounted on or recessed within a sloping surface.

7. Any fixture fed from more than one panel, i.e., for normal and night or emergency operation, shall
   have separate neutrals to each panel.

8. Furnish code-approved wiring in ceiling cavities forming air plenums.

B. Lamps:
   1. Hot cathode fluorescent lamps: warm white except as shown. Refer to fixture schedules
      on drawings. All lamps, except as specified, shall be of the same manufacturer (General
      Electric, GTE Sylvania, North American Philips, Osram, or equal).
   2. High intensity discharge lamps: Refer to fixture schedules on drawings. All lamps, unless
      specified otherwise, shall be of the same manufacturer (General Electric, GTE Sylvania,
      North American Philips, Osram or equal).

C. Where acrylic plastic is specified, use 100% raw virgin acrylic plastic meeting the ASTM Speci-
   fication for methacrylate molding compound equal to Rohm and Haas "Plexiglass", or equal
   (no known equal). The raw material used must be of the quality to exceed IES-SPI-NEMA
   Specifications with a minimum requirement of 2000 hours of exposure in a Fade-O-Meter and
   not exceed (3) units of yellowing. E.T.L. report to be supplied confirming above require-
   ments.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine substrate and supporting grids for luminaires.
   B. Examine each luminaire to determine suitability for lamps specified.

3.2 INSTALLATION: Electrical installation shall conform to requirements of NFPA 70, state codes,
   and to requirements specified herein.
   A. Provide a lighting fixture for each lighting outlet as indicated.
   B. Provide complete fixtures, including glassware, diffusers, lenses, fitters, canopies, sockets,
      reflectors, ballasts, wiring, hangers and any accessories necessary to complete each fixture
      installation.
   C. Provide spacers where required for surface-mounted fixtures mounted to low density cellu-
      lose or similar ceiling materials.
   D. Provide accessories as required for ceiling construction type indicated on Finish Schedule.
      Fixture catalog numbers do not necessarily denote specific mounting accessories for type of
      ceiling in which a fixture may be installed.
E. Provide adequate and sturdy support for each lighting fixture. Verify weight and mounting method of all fixtures and furnish and install suitable supports. Fixture mounting assemblies shall comply with all local seismic codes and regulations.

F. Install rows of fixtures accurately on straight lines unless otherwise indicated on drawings. Coordinate with mechanical work.

G. Install fixtures with vent holes free of air blocking obstacles.

H. Top Relamping Fixtures: Top relamping fixtures shall have the necessary top-relamping screws loosened and moderately tightened, prior to installation, to assure ease of operation when relamping is required.

I. Fluorescent Fixtures: Replace noisy ballasts as directed, at no cost to the Owner.

J. High Intensity Discharge Fixtures:
   1. Replace noisy ballasts as directed, at no cost to the Owner.
   2. Ballasts for indoor application shall be encased in a housing which provides necessary wiring compartments and provisions for required electrical connectors or devices.
   3. Ballast components shall be surrounded with a thermosetting fill to assure adequate heat dissipation and quiet operation.
   4. Ballasts shall be provided with necessary mounting hardware and vibration dampers.

K. Ballasts for outdoor use shall be encased in weathertight enclosures with proper outdoor type wiring devices. Ballasts shall be suitable for starting lamps between -29°C and 41°C.

L. Mask the trims and bottoms of all lighting fixtures if necessary to protect the fixture during construction.

M. At the completion of construction clean the bottoms, the trim, the reflecting surfaces, lenses, baffles, louvers and reflector cones of all lighting fixtures so as to render them free of any material, substance or film foreign to the fixture.

N. Ascertain and ensure that all lamps installed are exactly as specified for each fixture type.

O. Provide labor and materials for final targeting of all adjustable fixtures under the Owner’s Representative supervision. Targeting shall take place immediately before building is turned over to Owner, after regular working hours where required.

P. Replace all burned-out or inoperative lamps and inoperative ballasts in all high intensity discharge and fluorescent fixtures before the project is accepted by the Owner so that all lighting fixtures will be in first-class operating condition.

3.3 FIXTURE LOCATIONS

A. Locations of fixtures are shown diagrammatically. Verify exact location and spacing with Reflected Ceiling Plans and other reference data before ordering of fixtures and during installation.
   1. Notify Owner’s Representative about field conditions at variance with Contract Documents before commencing installation.
   2. Coordinate space conditions with other trades before ordering of fixtures.
   3. Coordinate length of continuous-run fluorescent fixtures with adjacent walls, partitions, coffers and other architectural elements as required.
B. Prior to installing fixture outlets, examine the plans of other trades in order to conform to all of the following conditions:

1. Locate fixtures to conform with reflected ceiling plans included in the Contract Drawings.
2. Fixtures shall not conflict with the installation of doors or cabinets.
3. Locate fixtures symmetrical with tile and wall material patterns and room dimensions.
4. Fixture outlets shall be accessible and fixtures shall hang clear of ducts and piping. Verify exposed duct and piping locations prior to rough-in of electrical outlets. Adjust outlet locations to coordinate with ducts and piping.
5. Follow indicated mounting heights. Obtain missing heights, if any, from Owner’s Representative.

3.4 EXPANSION SHIELD ANCHORS

A. Expansion shields may be used for supporting lighting fixtures instead of concrete inserts under the following conditions:

1. Fastenings and expansion shield anchors shall be one trade size larger than Specification requirements for fastenings used with concrete inserts.
2. Holes for expansion shield anchors, cinch anchors, etc., shall be self-drilled or drilled with carbide tipped, rotary type concrete drills. Do not drill holes with pneumatic or impact tools. Do not install fasteners in concrete by powder actuated methods.
3. Drill holes for expansion shields carefully in a workmanlike manner. Drill to the full depth of the expansion shield anchor and in a manner that will develop the full strength of the fastening.

3.5 INTERFACE WITH OTHER PRODUCTS

A. Interface with air handling accessories furnished and installed under Section 15855.

3.6 CLEANING

A. Clean electrical parts to remove conductive and deleterious materials.
B. Remove dirt and debris from enclosure.
C. Clean photometric control surfaces as recommended by manufacturer.
D. Clean finishes and touch up damage.

3.7 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for proper connection and operation. Provide minimum of 48 hours demonstration of luminaire operation.

END OF SECTION 16510