PROJECT MANUAL

For

SBN FAR DETECTOR BUILDING
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

Project Number 6-7-93
March 30, 2015

SPECIFICATION DIVISIONS 00 THROUGH 17

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TABLE OF CONTENTS

DIVISION 1 – GENERAL REQUIREMENTS

SECTION NO.	SECTION TITLE	PAGES
01230	ALTERNATES	2
01524	CONSTRUCTION WASTE MANAGEMENT AND RECYCLING	4
01572	INDOOR AIR QUALITY DURING CONSTRUCTION	5
01805	GENERAL REQUIREMENTS – DOE GUIDING PRINCIPLES	6
01810	COMMISSIONING	28

DIVISION 3 - CONCRETE

03300	CAST-IN-PLACE CONCRETE	20

DIVISION 4 - MASONRY

04200	UNIT MASONRY	13

DIVISION 5 - METALS

05120	STRUCTURAL STEEL FRAMING	9
05210	STEEL JOIST FRAMING	5
05310	STEEL DECKING	6
05500	METAL FABRICATIONS	10
05510	METAL STAIRS	7
05521	PIPE and TUBE RAILINGS	9
05700	DECORATIVE METAL SIGNAGE	7

DIVISION 6 – WOOD AND PLASTICS

06100	ROUGH CARPENTRY	7
06160	SHEATHING	3

DIVISION 7 – THERMAL AND MOISTURE PROTECTION

07115	BITUMINOUS DAMPPROOFING	3
07131	SELF-ADHERING SHEET WATERPROOFING	4
07180	TRAFFIC COATINGS	4
07210	BUILDING INSULATION	2
07413	INSULATED-CORE METAL WALL PANELS	8
07510	BUILT-UP BITUMINOUS ROOFING	7
07600	FLASHING and SHEET METAL	10
07720	ROOF ACCESSORIES	6
07841	THROUGH-PENETRATION FIRESTOP SYSTEMS	9
07842	FIRE-RESISTIVE JOINT SYSTEMS	7
07901	JOINT SEALANTS	9

DIVISION 8 – DOORS AND WINDOWS

08100	HOLLOW METAL DOORS AND FRAMES	10
08330	INSULATED COILING DOOR	6
08410	ALUMINUM ENTRANCES and STOREFRONTS	6
08452	INSULATED TRANSLUCENT WALL PANEL SYSTEM	8
08620	UNIT SKYLIGHTS	5
08712	DOOR HARDWARE	16
08810	GLAZING	12

08911	ALUMINUM-FRAMED CURTAIN WALL SYSTEM	7

DIVISION 9 - FINISHES

09260	GYPSUM BOARD ASSEMBLIES	13
09300	CERAMIC TILE	7
09511	ACOUSTICAL PANEL CEILINGS	7
09900	PAINTING and COATING	9

DIVISION 10 - SPECIALTIES

10200	LOUVERS, VENTS and SCREENS	7
10523	FIRE EXTINGUISHERS	3
10800	TOILET ACCESSORIES	5

DIVISION 15 - MECHANICAL

15010	BASIC MECHANICAL REQUIREMENTS	24
15080	THROUGH PENETRATION FIRESTOPPING	6
15140	SUPPORTS AND ANCHORS	11
15163	SUMP PUMPS	2
15170	MOTORS	4
15190	MECHANICAL IDENTIFICATION	4
15245	VIBRATION ISOLATION	8
15260	PIPING INSULATION	6
15290	DUCTWORK INSULATION	6
15310	FIRE PROTECTION SYSTEMS	9
15410	PLUMBING PIPING	23
15430	PLUMBING SPECIALTIES	4
15440	PLUMBING FIXTURES	3
15515	NATURAL GAS AND PROPANE PIPING	11
15780	PACKAGED ROOFTOP AIR CONDITIONING UNITS	7
15835	TERMINAL HEAT TRANSFER UNITS	4
15865	AXIAL FANS	3
15870	POWER VENTILATORS	2
15890	DUCTWORK	13
15910	DUCTWORK ACCESSORIES	4
15936	AIR INLETS AND OUTLETS	4
15952	CONTROLS	42
15980	INSTRUMENTATION	4
15990	TESTING, ADJUSTING AND BALANCING	7
15995	COMMISSIONING OF HVAC	2

DIVISION 16 – ELECTRICAL

16010	BASIC ELECTRICAL REQUIREMENTS	27
16016	POWER SYSTEM STUDY	5
16080	THROUGH PENETRATION FIRESTOPPING	
16111	CONDUIT AND BOXES	17
16120	WIRE AND CABLE	5
16141	WIRING DEVICES	27
16190	SUPPORTING DEVICES	4
16195	ELECTRICAL IDENTIFICATION	8
16412	SURGE PROTECTION DEVICES	6
16440	DISCONNECT SWITCHES	2
16450	GROUNDING AND BONDING	11
16461	DRY TYPE TRANSFORMERS	3
16470	PANELBOARDS	4

16477	FUSES	2
16480	MOTOR CONTROL	4
16481	VARIABLE FREQUENCY DRIVES	9
16495	TRANSFER SWITCH	4
16510	LIGHTING	4
16570	LIGHTING CONTROL SYSTEMS	9
16611	STATIC UNINTERRUPTIBLE POWER SUPPLY	19
16721	FIRE ALARM AND DETECTION SYSTEMS	46
16722	AIR SAMPLING SMOKE DETECTION SYSTEMS (ASSD)	10
16950	TESTING ELECTRICAL SYSTEMS	19
16995	COMMISSIONING OF ELECTRICAL	2

DIVISION 17 – TECHNOLOGY

17010	BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS	21
17050	COMMUNICATIONS BONDING	11
17110	COMMUNICATION EQUIPMENT ROOMS	3

SECTION 01230 - ALTERNATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for alternates.

1.3 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the Bidding Requirements that may be added to or deducted from the Base Bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.4 PROCEDURES

A. Coordination: Modify or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1. Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated modifications to alternates.

C. Execute accepted alternates under the same conditions as other work of the Contract.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate No. 1 - Remove the Mezzanine Level indicated on sheet A-2. Provide all embeds indicated on the structural drawings necessary to construct the Mezzanine in the future. Make no change to either Stair #1 or Stair #2 in this Alternate. All stair runs and landings shall be as indicated. Remove doors and hardware S051 and S052 in this Alternate. Construct the rough opening for these two openings so that they may be provided in the future. Infill the openings with a 6" CMU "knock-out" wall as a part of this Alternate. Remove sprinklers that may be attached to the underside of this Mezzanine as a part of this Alternate. Relocate any lighting attached to the underside of the steel mezzanine to the adjacent wall. All structural steel framing, steel grating, and steel handrails will be removed as part of this Alternate.

B. Alternate No. 2 – Electrical. Manufacturer's not included in the electrical specification as approved may bid the project as a voluntary alternate under this Alternate No. 2.

END OF SECTION 01230

SECTION 01524 - CONSTRUCTION WASTE MANAGEMENT AND RECYCLING

PART 1. GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Construction waste management plan.

2. Construction waste recycling.

1.03 PLAN REQUIREMENTS

A. Develop, submit, and implement a Construction Waste Management plan to recycle or salvage at least 50 percent of the non-hazardous construction, demolition and land clearing materials, excluding soil, for compliance with DOE Guiding Principle.

1.04 SUBMITTALS

A. Construction Plan: Submit construction waste management plan describing methods and procedures for implementation and monitoring compliance including the following:

1. Transportation company hauling construction waste to waste processing facilities.

2. Recycling and adaptive reuse processing facilities and waste type each facility will accept.

3. Construction waste materials anticipated for recycling and adaptive reuse.

4. On site sorting and site storage methods.

B. Submit documentation prior to Substantial Completion, substantiating construction waste management plan was maintained and goals were achieved.

1. Trash: Quantity by weight deposited in landfills. Include associated fees, transportation costs, container rentals, and taxes for total cost of disposal.

2. Salvaged Material: Quantity by weight with destination for each type of material salvaged for resale, recycling, or adaptive reuse. Include associated fees, transportation costs, container rentals, and taxes for total cost of disposal. Also include reimbursements due to salvage resale.

3. Total Cost: Indicate total cost or savings for implementation of construction waste management plan.

1.05 CONSTRUCTION WASTE MANAGEMENT PLAN

A. Construction Waste Landfill Diversion: Minimum 50 percent by weight of construction waste materials for duration of Project through resale, recycling, or adaptive reuse.

B. Implement construction waste management plan at start of construction.

C. Review construction waste management plan at pre-construction meeting and progress meetings

D. Distribute approved construction waste management plan to subcontractors and others affected by Plan Requirements.

E. Oversee plan implementation, instruct construction personnel for plan compliance, and document plan results.

1.06 CONSTRUCTION WASTE RECYCLING

A. The Contractor shall have the option of sorting the materials off-site or on-site.

1. Off-Site: If the Contractor chooses to sort the material off-site, he shall provide the name of the vendor, and provide procedures on the documentation of the recyclable waste.

2. On-Site: The contractor shall provide separate collection containers for a minimum of the following materials:

a) Untreated lumber.

b) Gypsum wallboard.

c) Paper, paper products, and cardboard.

d) Plastics.

e) Metals.

f) Glass.

g) Other salvageable materials.

1.07 CONSTRUCTION WASTE ADAPTIVE RE-USE

A. Arrange with processing facility for salvage of construction material and processing for reuse. Do not reuse construction materials on site except as accepted by Owner.

1.08 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable local ordinances and regulations

B. Disposal Sites, Recyclers, and Waste Materials Processors: Use only facilities properly permitted by the State of Illinois, and by local authorities where applicable.

C. Prior to beginning work at the site, schedule and conduct a conference to review the Construction Waste Management Plan and discuss procedures, schedules and specific requirements for waste materials recycling and disposal. Discuss coordination and interface between the Subcontractor and other construction activities. Identify and resolve problems with compliance with requirements. Record minutes of the meeting, identifying all conclusions reached and matters requiring further resolution.

1. Attendees: The Subcontractor and related Subcontractor personnel associated with the work of this section, including personnel to be in charge of the waste management program; the Construction Quality Manager; CC; and such additional personnel as Fermilab deems appropriate.

2. Plan Revision: Make any revisions to the Construction Waste Management Plan agreed upon during the meeting and incorporate resolutions agreed to be made subsequent to the meeting. Submit the revised plan to Fermilab for approval.

D. Implementation: Designate an on-site person responsible for instructing workers and implementing the Construction Waste Management Plan. Distribute copies of the Construction Waste Management Plan to the job site foreman and each subcontractor. Post Waste Management Plan on the job site bulletin board. Include waste management and recycling in worker orientation and review periodically. Provide on-site instruction on appropriate separation, handling, recycling, and salvaging methods to be used by all parties at the appropriate stages of the work at the site. Include waste management and recycling discussion in pre-fabrication meetings with subcontractors and fabricators. Also include discussion of waste management and recycling in regular job meetings and job safety meetings conducted during the course of work at the site.

PART 2. PRODUCTS - Not Used

PART 3. EXECUTION

3.01 CONSTRUCTION WASTE COLLECTION

A. Collect construction waste materials in marked bins or containers and arrange for transportation to recycling centers or adaptive salvage and reuse processing facilities. Remove all indicated recyclable materials from the work location to approved containers daily. Failure to remove waste materials will be considered cause for withholding payment and termination of Contract

B. Change out loaded containers for empty ones as demand requires, but not less than weekly.

C. Handling: Deposit all indicated recyclable materials in the containers in a clean (no mud, adhesives, solvents, petroleum contamination), debris-free condition. Do not deposit contaminated materials into the containers until such time as such materials have been cleaned.

D. If the contamination chemically combines with the material so that it cannot be cleaned, do not deposit into the recycle containers. In such case, request resolution by the Construction Quality Manager as to disposal of the contaminated material. Directions from the Construction Quality Manager do not relieve the Subcontractor from compliance with all legal and regulatory requirements for disposal, nor shall such directions cause a request for modification of the Contract

E. Maintain recycling and adaptive reuse storage and collection area in orderly arrangement with materials separated to eliminate co-mingling of materials required to be delivered separately to waste processing facility.

F. Store construction waste materials to prevent environmental pollution, fire hazards, hazards to persons and property, and contamination of stored materials.

G. Cover construction waste materials subject to disintegration, evaporation, settling, or runoff to prevent polluting air, water, and soil.

3.02 CONSTRUCTION WASTE DISPOSAL

A. Deliver construction waste to waste processing facilities. Obtain receipt for deliveries.

B. Dispose construction waste not capable of being recycled or adaptively reused by delivery to landfill, incinerator, or other legal disposal facility. Obtain receipt for deliveries.

END OF SECTION 01524

SECTION 01572 - INDOOR AIR QUALITY DURING CONSTRUCTION

PART 1. GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Construction indoor air quality (IAQ) management plan.

2. HVAC air filters.

3. Building flush-out.

1.03 PLAN REQUIREMENTS

A. Develop, submit and implement construction IAQ management plan in accordance with SMACNA IAQ “Guidelines For Occupied Building Under Construction”, for compliance with the DOE Guiding Principle requirement. The plan shall include building flushout after construction and prior to occupancy.

1.04 SUBMITTALS

A. Product Data: Submit description and performance data for filters, including MERV ratings.

B. Construction Plan: Submit construction IAQ management plan describing methods and procedures for implementation and monitoring compliance.

1.05 CLOSEOUT SUBMITTALS

A. Project Record Documents: Submit construction photographs showing compliance with construction IAQ management plan.

B. Flushout documentation: Submit signed letter documenting that the building flushout is successfully accomplished in accordance with the approved IAQ management plan.

1.06 CONSTRUCTION IAQ MANAGEMENT PLAN

A. HVAC PROTECTION

1. Seal off all supply louvers, return air grilles, and air intake/discharge points to prevent construction dust and debris from entering.

2. Seal off all ductwork openings and air outlets with plastic sheeting to protect the duct system from dust and debris. Do not re-open until the end of activities that produce dust or pollution, such as drywall sanding, concrete cutting, masonry work, wood sawing, and so forth.

3. If for some unforeseen reason, there should arise a circumstance wherein the return air system is required to be used during the construction phase, install temporary filters (as determined by ASHRAE Standard 52.2-1999 and of type as used in the final installation) at each return air opening and supply air intakes, and provide frequent inspection and maintenance. If inspections by CC or Commissioning Agent reveal that the ductwork has become contaminated due to inadequate protection, the ductwork shall be cleaned professionally prior to the first phase of occupancy, using procedures established in ACR 2005 published by the National Air Duct Cleaners Association. Replace these filters prior to building flushout.

4. Under no circumstances shall air be returned from a construction area and then recirculated through the permanent supply ductwork, unless and until the level of construction in the relevant area involves final finishes and trim and the construction has reached a point of complete building dry-in with no sanding and is free from dust, debris, and contaminants.

5. Do not use fan rooms to store construction or waste materials, and keep them clean and neat.

B. SOURCE CONTROL

1. Limit construction traffic and motor idling in the vicinity of air intake louvers when the HVAC systems are activated. Restrict motor vehicles to areas well-removed from air intakes, preventing emissions from being drawn into the building.

2. Use electric or natural gas alternatives for gasoline and diesel equipment where possible and practical.

3. Cycle equipment off when not being used or needed.

4. Avoid the use of materials and products with high VOC and/or particulate levels. Use products and installation methods with low VOCs such as paints, sealers, insulation, adhesives, caulking and cleaners. Comply with the requirements in other Specification Sections.

5. Keep containers of wet products closed as much as possible. Cover and seal waste materials which can release odor or dust.

6. Protect all materials, especially absorbent materials such as insulated ductwork, against moisture during delivery to and storage at the job site. Store materials inside the structure in a dry and clean environment pending installation

C. PATHWAY INTERRUPTION

1. Use dust curtains or temporary enclosures to prevent dust from migrating to other areas when applicable. During construction, isolate areas of work to prevent contamination of clean or occupied areas.

2. Keep pollutant sources as far away as possible from ductwork and areas occupied by workers when feasible.

3. Isolate work areas and/or create pressure differentials to prevent the migration of contaminants.

4. Use portable fan systems to exhaust contaminated air directly to the outside of the building, and discharge the air in a means to prevent it from re-entering

D. HOUSEKEEPING

1. General housekeeping, and dust suppression programs shall include the use of wetting agents or sweeping compounds. Use efficient and effective dust collecting methods such as damp cloths, wet mops, and vacuums with particulate filters, or wet scrubbers. Institute cleaning activities of building areas on a daily basis, and of HVAC equipment as required.

2. Keep all coils, air filters, dampers, fans, and ductwork clean during installation, and clean them as required prior to performing the testing, adjusting and balancing of the systems.

3. Avoid accumulations of water inside the building, and promptly remove any that may occur. Especially protect porous materials such as insulation and ceiling tiles from exposure to moisture

4. Provide photographs of the above activities during construction to document compliance

E. SCHEDULING

1. Sequence construction activities carefully over the duration of the project to minimize the impact on IAQ. Plan adequate time to conduct flushout before occupancy.

2. Install new filters, of types required and specified for the final installation, at the central fan system, immediately prior to occupancy for each respective.

PART 2. PRODUCTS

2.01 HVAC AIR FILTERS

A. Return Filters: Filtration media rated for minimum efficiency reporting value (MERV) when tested in accordance with ASHRAE 52.2.

1. Construction Return Filters: MERV of 8, minimum.

2. Flush-Out Return Filters: MERV of 13, minimum.

3. Permanent Filters: As specified in Mechanical Section or Equipment Schedule

PART 3. EXECUTION

3.01 IAQ PLAN

A. Implement Construction IAQ Management Plan at start of construction.

B. Review Construction IAQ management plan at pre-construction meeting and progress meetings

C. Distribute approved Construction IAQ Management Plan to subcontractors and others affected by Plan Requirements.

D. Oversee plan implementation, instruct construction personnel for plan compliance, and document plan results.

3.02 FILTER INSTALLATION AND REPLACEMENT

A. Install construction return filter at each return grille before operating permanent air handlers during construction.

B. Replace filters after completing construction and before conducting building flush-out.

1. Replace construction return filters with flush-out return filters.

2. Replace supply filters.

C. Replace filters after conducting building flush-out and before occupancy.

1. Replace flush-out return filters with permanent filters.

2. Replace supply filters.

3.03 BUILDING FLUSH-OUT

A. Conduct building flush-out after construction ends and before occupancy for minimum 72 hours with maximum outdoor air consistent with achieving indoor relative humidity no greater than 60 percent.

3.04 CONSTRUCTION PHOTOGRAPHS

A. Photograph construction operations to show compliance with SMACNA IAQ and construction IAQ management plan.

1. Take minimum six photographs on minimum three different occasions during construction to show consistent adherence with specified requirements.

END OF SECTION 01572

SECTION 01805 – GENERAL REQUIREMENTS – DOE GUIDING PRINCIPLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements and procedures for compliance with U.S. Department of Energy's Guiding Principles for New Construction. The goal of these Guiding Principles for Sustainable Buildings is to design buildings to be energy efficient, conserver resources, and provide comfortable and healthy environments for occupants.

B. Guiding Principles Items incorporated into the Design:

1. Commissioning
2. Energy Efficiency
3. Measurement and Verification
4. Indoor Water – Water Savings
5. Indoor Water – Measurement and Verification
6. Water Efficient Products
7. Ventilation and Thermal Control
8. Moisture Control
9. Day-lighting
10. Day-lighting – Lighting Controls

C. Guiding Principles Items to be incorporated during Construction:

1. Commissioning
2. Low-emitting Materials
3. Air Quality during Construction
4. Recycled Content
5. Bio-based Content
6. Environmentally Preferable Products
7. Waste and Materials Management
8. Ozone Depleting Compounds

1.2 DEFINITIONS

A. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

B. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Respond to questions and requests from Fermilab regarding Guiding Principles Construction Items that are the responsibility of the Contractor, that depend on product selection or product qualities, or that depend on Contractor's procedures. Document responses as informational submittals.

1.4 ACTION SUBMITTALS

A. General: Compliance with the requirements of the Guiding Principles goals shall be clearly indicated on the action submittals required by other Specification Sections.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Provide products and procedures necessary to comply with Guiding Principles outlined in this Section. Although other Sections may specify some requirements that contribute to compliance with the Guiding Principles, the Contractor shall determine additional materials and procedures necessary to comply.

2.2 COMMISSIONING

A. Objective: To employ commissioning tailored to the building, including commissioning requirements in construction documents, a commissioning plan, verification and a final report.

B. Implementation:

1. Refer to specification section 01810 – Commissioning
2. Refer to Specification section 15995 – Commissioning of HVAC Systems

2.3 LOW-EMITTING MATERIALS

A. Objective: Use materials and products inside the weatherproofing system of the building that have low pollutant emissions, including composite wood products, adhesives, sealants, interior paints and finishes, carpet systems, and furnishings.

B. Implementation: All submittals

1. Adhesives and Sealants shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

a) Wood Glues: 30 g/L.
b) Metal-to-Metal Adhesives: 30 g/L.
c) Adhesives for Porous Materials (Except Wood): 50 g/L.
d) Subfloor Adhesives: 50 g/L.
e) Plastic Foam Adhesives: 50 g/L.
f) Carpet Adhesives: 50 g/L.
g) Carpet Pad Adhesives: 50 g/L.
h) VCT and Asphalt Tile Adhesives: 50 g/L.
i) Cove Base Adhesives: 50 g/L.
j) Gypsum Board and Panel Adhesives: 50 g/L.
k) Rubber Floor Adhesives: 60 g/L.
l) Ceramic Tile Adhesives: 65 g/L.
m) Multipurpose Construction Adhesives: 70 g/L.
n) Fiberglass Adhesives: 80 g/L.
o) Contact Adhesive: 80 g/L.
p) Structural Glazing Adhesives: 100 g/L.
q) Wood Flooring Adhesive: 100 g/L.
r) Structural Wood Member Adhesive: 140 g/L.
s) Single-Ply Roof Membrane Adhesive: 250 g/L.
t) Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine-covered board, metal, unsupported vinyl, rubber, or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
u) Top and Trim Adhesive: 250 g/L.
v) Plastic Cement Welding Compounds: 250 g/L.
w) ABS Welding Compounds: 325 g/L.
x) CPVC Welding Compounds: 490 g/L.
y) PVC Welding Compounds: 510 g/L.
z) Adhesive Primer for Plastic: 550 g/L.
aa) Sheet-Applied Rubber Lining Adhesive: 850 g/L.
bb) Aerosol Adhesive, General-Purpose Mist Spray: 65 percent by weight.
cc) Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
dd) Special-Purpose Aerosol Adhesive (All Types): 70 percent by weight.
ee) Other Adhesives: 250 g/L.
ff) Architectural Sealants: 250 g/L.
gg) Nonmembrane Roof Sealants: 300 g/L.
hh) Single-Ply Roof Membrane Sealants: 450 g/L.
ii) Other Sealants: 420 g/L.
jj) Sealant Primers for Nonporous Substrates: 250 g/L.
kk) Sealant Primers for Porous Substrates: 775 g/L.
ll) Modified Bituminous Sealant Primers: 500 g/L.
mm) Other Sealant Primers: 750 g/L.

2. Paints and Coatings shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
    a) Categories in subparagraphs below are taken from LEED rating systems and the standards referenced by them; if clarification is required, see those documents or the reference guides.
    b) Flat Paints and Coatings: VOC not more than 50 g/L.
    c) Nonflat Paints and Coatings: VOC not more than 150 g/L.
    d) Dry-Fog Coatings: VOC not more than 400 g/L.
    e) Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
    f) Anticorrosive and Antirust Paints Applied to Ferrous Metals: VOC not more than 250 g/L.
    g) Zinc-Rich Industrial Maintenance Primers: VOC not more than 340 g/L.
    h) Pretreatment Wash Primers: VOC not more than 420 g/L.
    i) Clear Wood Finishes, Varnishes: VOC not more than 350 g/L.
    j) Clear Wood Finishes, Lacquers: VOC not more than 550 g/L.
    k) Floor Coatings: VOC not more than 100 g/L.
    l) Shellacs, Clear: VOC not more than 730 g/L.
    m) Shellacs, Pigmented: VOC not more than 550 g/L.
    n) Stains: VOC not more than 250 g/L.

3. Composite wood, agrifiber products, and adhesives shall not contain urea-formaldehyde resin.
    a. Also refer to section 06412 Plastic Laminate Faced Architectural Cabinets and section 06417 – Plastic Laminate Clad Countertops.

2.4 AIR QUALITY DURING CONSTRUCTION

A. Objective: Follow Sheet Metal and Air Conditioning Contractor's National Association Indoor Air Quality Guidelines 2007. Continue after construction for 72 hours.

B. Implementation:

1. Refer to specification section 01572 – Indoor Air Quality During Construction

2.5 RECYCLED CONTENT OF MATERIALS

A. Objective: Building materials shall have recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content for Project constitutes a minimum of 10, but possibly as much as 20 percent of cost of materials used for Project.

1. Cost of post-consumer recycled content plus one-half of pre-consumer recycled content of an item shall be determined by dividing weight of post-consumer recycled content plus one-half of pre-consumer recycled content in the item by total weight of the item and multiplying by cost of the item.
2. Do not include **furniture,** plumbing, mechanical and electrical components, and specialty items such as elevators and equipment in the calculation.

B. Implementation: Select suppliers and vendors for the following materials that will make the project meet the target:

1. Cast-in-Place Concrete
2. Concrete Reinforcing
3. Structural and Miscellaneous Steel
4. Metal Wall and Roofing Systems
5. Metal Doors and Frames
6. Glazing
7. Aluminum Framed Windows and Curtain-walls
8. Metal Stud Framing
9. Gypsum Board

C. Additional Requirements in specific sections:
1. Refer to section 02370 – Erosion Control – for Riprap
2. Refer to section 09580 – Suspended Decorative Grid Ceiling.

2.6 BIOBASED CONTENT

A. Objective: Use Building materials that use biobased carbon content in lieu of fossil carbon content (coal or petroleum).

B. Implementation: Select suppliers and vendors for the following materials that will make the project meet the target:

1. Paving and Concrete Forming
2. Lumber and Millwork
3. Paintings and Coatings
4. Sealants

2.7 ENVIRONMENTALLY PREFERABLE PRODUCTS

A. Objective: Use Building materials that have less impact on human health and the environment over their lifecycle.

B. Implementation: Refer to sections above:

1. Low-emitting Materials
2. Recycled Material Content
3. Biobased content

2.8 WASTE AND MATERIALS MANAGEMENT

A. Objective: Recycle at least 50% of Construction waste during construction.

B. Implementation:

1. Refer to section 01524 – Construction Waste Management and Recycling.

2.9 OZONE DEPLETING COMPOUNDS

A. Objective: Eliminate the use of ozone-depleting compounds during and after construction. Do not use materials containing CFC or HCFC compounds. Do not use equipment using CFC refrigerants.

B. Implementation:

1. Refer to section 07413 – Insulated-Core Metal Wall Panels
2. Refer to section 15083 – HVAC Insulation
3. Refer to section 15085 – Plumbing Piping Insulation
4. Refer to section 15427 – Pressure Water Coolers
5. Refer to section 15732 – Packaged, Outdoor, Central-Station Air-Handling Units

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01805

SECTION 01810 - COMMISSIONING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Commissioning Process
C. Related Work

1.2 DESCRIPTION

A. Commissioning. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing, adjusting and balancing, performance testing and training.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify applicable equipment and systems are installed according to the Owner's Project Requirements, manufacturer's recommendations, and industry accepted minimum standards.
2. Verify applicable equipment and systems receive adequate operational checkout by installing contractors.
3. Observe and document proper performance of equipment and systems.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

D. Abbreviations. The following are common abbreviations which may be used in the *Specifications* and the *Commissioning Plan.*

A/E	Architects and Engineers
BOD	Basis of Design
Cx	Commissioning
CAL	Commissioning Actions Log
CxA	Commissioning Authority
CxS	Commissioning Specialist
CM	Construction Manager
CC	Controls Contractor
DB/C	Design Build Contractor
EC	Electrical Contractor
FAR	Field Activity Report
FPT	Functional Performance Test
GC	General Contractor
IST	Integrated Systems Test
LEED	Leadership in Energy and Environmental Design
MFR	Manufacturer
MC	Mechanical Contractor
O&M	Operation and Maintenance
OPR	Owner's Project Requirements
PFC	Pre-Functional Checklist
Subs	Subcontractors to General Contractor
TAB	Test, Adjust & Balance

1.3 COMMISSIONING PROCESS

A. Commissioning Plan. The commissioning plan (Cx Plan), which is in the appendix to this specification, provides definition for the execution of the commissioning process. The Commissioning Authority (CxA) shall update the Cx Plan throughout the course of the Cx Process.

B. Commissioning Process. For an overview of the typical commissioning tasks during construction and the general order in which they occur, refer to the Cx Plan.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section.

1. Commissioning Plan (Cx Plan)
2. Section 15995 - Commissioning of Mechanical
3. Section 16995 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout, and functional performance testing shall be provided by the Division Contractor. If required, two-way radios, ladders and/or man-lifts shall be provided by the General Contractor or applicable Subcontractor.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of this specification section.

END OF SECTION 01810

Fermilab

SBN Far Detector Building

Commissioning Plan

KJWW Engineering

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TABLE OF CONTENTS

1.0 | OVERVIEW 4

Project Introduction 5

General Building Information 5

Abbreviations and Definitions 5

2.0 | COMMISSIONING PLAN 6

Purpose 7

Commissioning Definition 7

Systems to be Commissioned 8

Sampling and Retesting Strategy 8

Commissioned Equipment List 8

3.0 | COMMISSIONING TEAM 9

Commissioning Team 10

4.0 | COMMISSIONING PROCESS 11

Commissioning Process 12

Design Phase 12

Contract Documents 12

Commissioning Plan 12

Commissioning Specifications 12

Construction Phase 13

Commissioning Kickoff Meeting 13

Commissioning and Project Meetings 14

Equipment Submittals and Documentation 14

Site Observations 15

Pre-Functional Checklists, Tests, and Startup 15

Equipment Startup 17

Field Quality Control Testing 17

BAS Integration Meeting 17
BAS Point to Point 18
Testing, Adjusting and Balancing 18

Acceptance Phase 19
Commissioning Meetings 19
Site observations 19
Functional Performance Tests 19
Functional Performance Test Review 20
Final Test Scheduling 20
Functional Performance Testing 21
Deficiencies, Re-testing, and Acceptance 21
Commissioning Actions Log (CAL) 21

Occupancy Phase 23
Operations and Maintenance Manuals 23
Final Summary Report 23
Seasonal Testing 23

5.0 | APPENDIX 24

Example Commissioning Activities 25

REVISION HISTORY AND PLAN ACCEPTANCE

Issued for Pricing ..... January 14, 2015

Issued for Review ..... [DATE]

Issued for Approval ..... [DATE]

Issued for Record ..... [DATE]

_____ date _____
Commissioning Authority

_____ date _____
Owner Representative

_____ date _____
Designer Representative

_____ date _____
General Contractor

_____ date _____
Mechanical Contractor Representative

_____ date _____
Electrical Contractor Representative

_____ date _____
Controls Contractor Representative

_____ date _____
TAB Contractor Representative

1.0 | Overview

Project Introduction

KJWW is providing design phase commissioning services for the new Fermilab SBN Far Detector Building located in Batavia, Illinois. This commissioning will be done in accordance with the "Guiding Principles for Sustainable New Construction and Major Renovations" per the requirements of the Department of Energy's "Guiding Principles for High Performance Sustainable Buildings." These commissioning requirements approximate those required by LEED Fundamental Commissioning, but without the OPR and BOD requirements.

General Building Information

Project:	SBN Far Detector Building
Location:	Batavia, Illinois
Building Type:	Laboratory
Square Footage:	[Square Footage]
Number of Stories:	[Number of Stories]
Construction Period:	[Construction Period]

Abbreviations and Definitions

The following are common abbreviations, not all of which may be used in this document:

A/E	Architects and Engineers
BOD	Basis of Design
Cx	Commissioning
CAL	Commissioning Actions Log
CxA	Commissioning Authority
CxS	Commissioning Specialist
CM	Construction Manager
CC	Controls Contractor
DB/C	Design Build Contractor
EC	Electrical Contractor
FAR	Field Activity Report
FPT	Functional Performance Test
GC	General Contractor
IST	Integrated Systems Test
LEED	Leadership in Energy and Environmental Design
MFR	Manufacturer
MC	Mechanical Contractor
O&M	Operation and Maintenance
OPR	Owner's Project Requirements
PFC	Pre-Functional Checklist
Subs	Subcontractors to General
TAB	Testing, Adjusting, and Balancing Contractor

2.0 | Commissioning Plan

Purpose

The Commissioning Plan is a management and communications tool that defines the scope, standards, processes, roles and responsibilities, expectations, and deliverables for the project. It is a dynamic document that is revised and refined as the phases of the project progress.

The plan also defines the equipment and systems, commissioning requirements, and addresses the integration of commissioning into the overall project delivery process. This plan is intended to assist members of the Project Team in applying a clear and consistent approach to commissioning during all phases of project delivery.

The CxA develops the Cx Plan using input from the commissioning team. The plan includes the following:

- Commissioning Team. Defines the roles and responsibilities of the team members.
- Commissioning Scope of Work. This describes in detail the scope of work and the roles and responsibilities, identifies the equipment and systems to be commissioned and defines the related commissioning specification requirements.
- Commissioning Forms. A description of the checklist and test forms to be completed.

The Owner, Design Consultants, and Contractor shall review the Cx Plan with the CxA. The approved document will be distributed to the Commissioning Team for information and action. As changes or modifications are needed, the CxA will incorporate them and redistribute the Cx Plan for approval.

Commissioning Definition

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.

Commissioning is not a replacement for good design and construction practices but is seen as a means to enhance the delivery process. The process consists of a series of checks and balances to ensure that the work is designed, installed and proven to operate as intended. Commissioning facilitates the transition from programming through design into construction and operations.

Systems to be Commissioned

Mechanical Systems (and all integral equipment controls)

- Heating, ventilating, air conditioning and refrigeration (HVAC&R) systems (mechanical and passive)
- Testing, adjusting, and balancing work
- Building automation system (controlled devices, control loops, and system integration)

Electrical Systems

- Lighting and Daylighting controls

Plumbing Systems

- Domestic hot water systems

Sampling and Retesting Strategy

All systems/equipment will be commissioned at 100% with 0% failure limit.

Commissioned Equipment List

At the conclusion of the project, the CxA will have gathered all equipment from the construction documents and coordinated the applicable information into a database. This database will associate the architectural naming tag, designed physical location and intended manufacturer and model number, if provided. This information will be made available to the Owner for initial review. At the conclusion of the project and through the Commissioning process, the initial data collection may be updated by the Commissioning Team with as-built information. The database can be exported and provided to the Owner at any time for inclusion in the Owner's Computerized Maintenance Management System (CMMS).

3.0 | Commissioning Team

Commissioning Team

Role	Company		Point of Contact				
	Name	Address	Name	Title	Phone Number	Cellular Number	Email Address
Example	*KJWW Engineering*	*231 S. LaSalle Street, Suite 600, Chicago, IL*	*John Doe*	*PM*	*(999) 999-9999*	*(999) 999-9999*	*JohnDoe@kjww.com*
Owner's Representative							
Construction Manager							
Architect of Record							
Commissioning Authority	KJWW Engineering	231 S. LaSalle Street, Suite 600, Chicago, IL 60604		CxA			
Commissioning Specialist	KJWW Engineering	231 S. LaSalle Street, Suite 600, Chicago, IL 60604		CxS CxS			
Mechanical Engineer							
Electrical Engineer							
General Contractor							
Mechanical Contractor							
Electrical Contractor							
Plumbing Contractor							
Controls Contractor							
Testing, Adjusting, Balancing Contractor							
Technology Contractor							
Fire Protection Contractor							

4.0 | Commissioning Process

Commissioning Process

The following sections sequentially detail the commissioning process by task through each phase of the project while incorporating the Roles and Responsibilities of the Commissioning Team.

Design Phase

Task	Owner	Architect	CxA	Engineer
Design Documents	Review & Approve	Develop & Respond	Review	Develop & Respond
Cx Plan	Review & Approve	Review & Approve	Develop & Manage	Review & Approve
Cx Specifications	Review	Incorporate	Develop & Manage	Incorporate

Contract Documents

The CxA shall review the design documents for familiarization only and coordination of the Commissioning requirements into the Cx Plan and Cx Specifications.

Commissioning Plan

As detailed earlier, the CxA develops and manages any updates to the Commissioning Plan. It is the responsibility of each Cx Team member to review and comment on the process and expectation of each individual and company defined in the Cx Plan. Acceptance prior to project completion is a requirement.

Commissioning Specifications

The CxA develops the commissioning specification sections and coordinates the integration of the commissioning requirements into the remainder of the project specifications. This will ensure that all systems and equipment to be commissioned are clearly identifiable by the general contractor and their subcontractors for accurate pricing.

Construction Phase

Task	Owner	Design Team	CxA	GC	Sub/Vendors
Commissioning Meetings	Attend	Attend	Lead	Attend	Attend
Equipment Submittals and Documentation	Review	Approve	Review	Submit	Submit
Site Observations	Attend	--	Perform & Document	Coordinate	Support
Pre-Functional Checklists	--	Review	Develop & Approve	Review & Perform	Review & Perform
Equipment Startup	Attend	Review & Approve	Review	Coordinate	Perform & Document
Field Quality Control Testing	--	Review & Approve	Review	Approve & Submit	Perform & Document
BAS Integration Meeting	--	Review & Approve	Review	Coordinate	Perform & Document
BAS Point to Point	--	Review & Approve	Review	Coordinate	Perform & Document
Testing, Adjusting and Balancing	--	Review & Approve	Review	Coordinate	Perform & Document

Commissioning Kickoff Meeting

The respective representatives of the GC, CxA, Owner's Representative, A/E, and the mechanical, electrical, technology, fire protection, controls, and TAB subs should be in attendance as required. At the inception of the Construction Phase, our team will organize and hold a Kickoff Meeting with all interested parties. The intent of this meeting is to introduce the contractors to the accepted commissioning process as determined in the Design Phase. This is done through a presentation overview of the process and distribution of the Cx Plan.

A typical kickoff meeting agenda would include:

a. CxA introduction
b. Team introductions with roles related to startup and schedule
c. Review of the commissioning process
d. Determine management and reporting
e. Flow of documents
f. Submittal data the CxA will receive

g. Review of this Commissioning Plan
h. Discussion of schedule, and determination of major deadlines and milestones
i. Questions

The goal of the meeting is to promote an increased understanding by all parties of the commissioning process and their respective responsibilities. The meeting provides the CxA additional information needed to finalize the Commissioning Plan, including the commissioning schedule and Cx points of contact

Commissioning and Project Meetings

The CxA can attend selected planning and job site meetings to remain informed of the construction progress and to update the parties involved in commissioning. The GC and A/E provide the CxA with information regarding substitutions and change orders that may affect commissioning equipment, systems, or the commissioning schedule.

The CxA will coordinate with the Contractor and Owner to schedule Commissioning meetings in conjunction with regular progress meetings. An agenda will be developed by the CxA and distributed to the Commissioning Team.

A typical Cx project meeting agenda would include:

a. Schedule review
b. PFC status
c. Equipment start-up status
d. FPT status
e. Recap of upcoming activites relating to commissioning
f. Commissioning Actions Log review
g. Site visit (before or after the meeting)

Dates, times and prerequisites for upcoming Commissioning checks, start-ups, or tests will be established. Issues will be raised and problems identified with required action decided, and a date for completion determined. Commissioning Team members are responsible for attending Commissioning meetings and for completing assigned action items by the assigned dates. The CxA will document meeting minutes and distribute within five (5) working days from the meeting for comment and revision by the Commissioning Team.

Equipment Submittals and Documentation

The contractor provides the Approved final record submittals to the CxA for the purpose of developing PFCs and FPTs.

The subcontractors, GC, or A/E shall notify the CxA of any new design intent, operating parameter changes, added control strategies and sequences of operation, or other change orders, RFI's, ASI', etc. that may affect commissioned systems. The controls contractor provides the CxA a full points list with descriptions. As the phases of TAB are completed, the draft TAB report is provided to the CxA with full explanations of approach, methods, results, data table legends, etc. The final approved TAB report is provided to the CxA upon completion.

Site Observations

The CxA makes periodic visits to the site, as necessary, to witness equipment and system installations. Field Activity Reports (FARs) will be issued to document activities, observations and any issues or deficiencies. These will be issued to the Owner and the rest of the construction team as necessary.

Pre-Functional Checklists, Tests, and Startup

Pre-Functional Checklists (PFC) are important to ensure that the equipment and systems are installed, operational and that functional performance testing may start without any unforeseen delays. Each piece of equipment receives full pre-functional checkout by the contractor. The PFC for a given piece of equipment must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

PFC's are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., oil levels, fan belt tension, gages in place, piping complete, etc.). The PFCs are made up of (3) three parts: equipment data, nameplate data and installation checks.

- **Equipment Data**: Used to capture information a maintenance management system would typically require, i.e.: tag no., make, model, serial no., location.
- **Nameplate Data**: Used to capture relevant nameplate data from the actual equipment installed. This can be compared to the approved equipment to ensure that the proper piece of equipment has been installed.
- **Installation Checks**: Used to verify that the equipment has been properly installed and is ready for startup.

Contractors typically already perform some, if not most, of the PFC items the CxA will require. However, few contractors document in writing the execution of these checklist items. PFCs ensure that these procedures are documented in writing by the installing technician. The CxA does not witness many of the PFCs, except for the larger or more critical pieces of equipment and random samples of other equipment and systems.

The GC is responsible for maintaining and gathering all PFC's for return to the CxA. An on-site binder may be used that can be checked out from the GC to complete checks, and then returned to be available to other contractors. The project-approved method is shown below in Diagram 3.

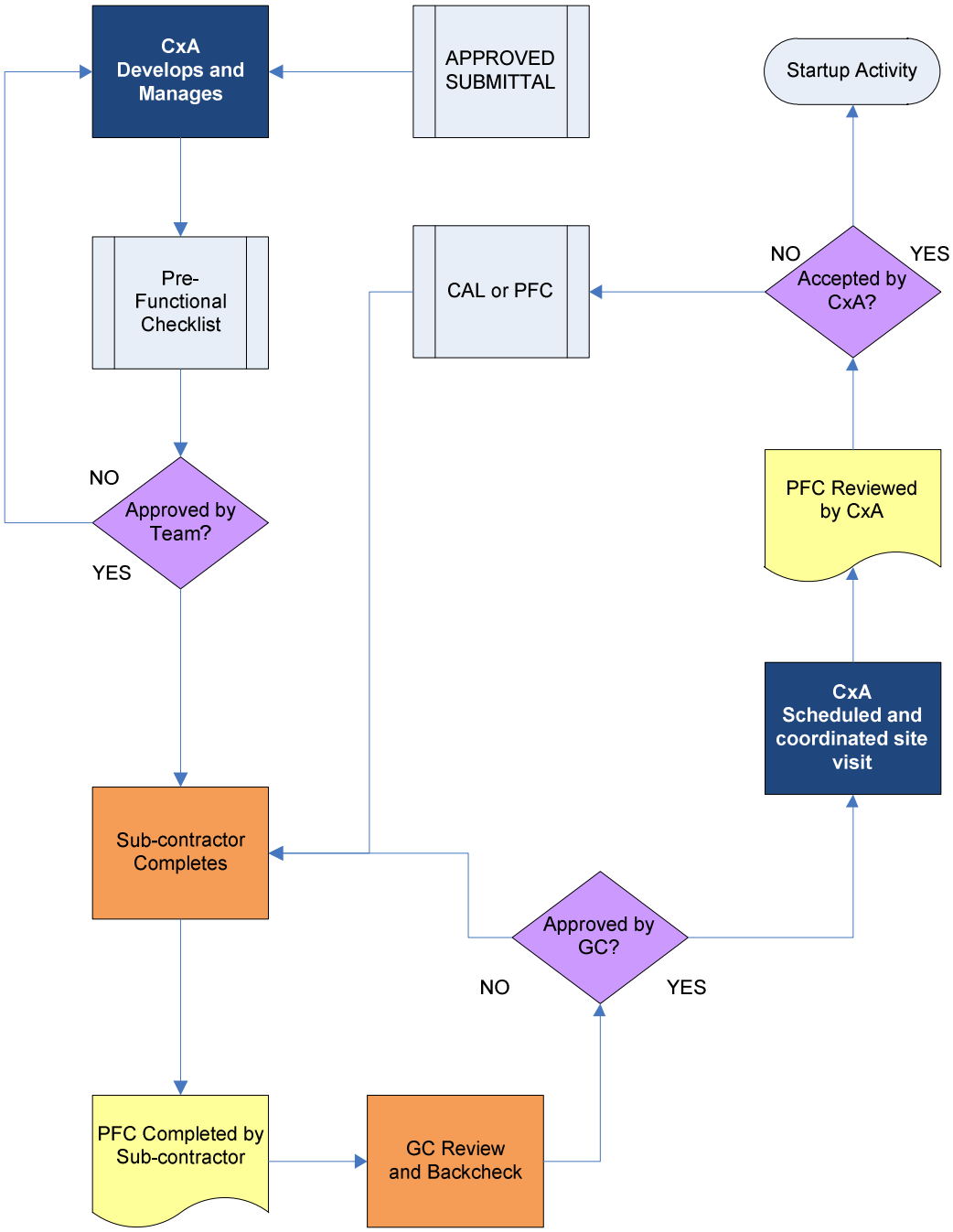

Diagram 1 - Pre-Functional Checklist Process

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Equipment Startup

The start-up process is scheduled by the subcontractor responsible for the equipment and the systems being started. The subcontractor prepares an overall schedule of startup activities for the team to review. The CxA witnesses the startup of major equipment and systems, as well as coordinates the schedule to allow the Owner staff the ability to witness the process as well.

The subcontractor executes equipment startup according to the startup plan and provides the CxA with a signed and dated copy of completed start-up plan documents. The subcontractor must notify the CxA in writing within 2 weeks of any outstanding items from the initial start-up process. The CxA will document these items in the CAL so their resolution can be tracked and recorded. Outstanding items must be satisfactorily addressed and documented within 2 weeks of start-up. All startup procedures must be satisfactorily executed before functional testing begins and before the equipment is operated, even temporarily.

Once the equipment and systems are started, the subcontractor is responsible for maintaining the warranty of the equipment. At a minimum, the subcontractor shall develop and submit a temporary use plan for the equipment that shows the hours of operations, routine maintenance plans and a sign-off form documenting who and when maintenance was performed. The plan will be kept on site and available for review by the team as needed. The plan will be turned over to the CxA at the completion of the project for inclusion with the Final Cx Report.

Field Quality Control Testing

The subcontractor is responsible for coordinating and preparing any field quality control testing for the CxA to witness. Examples of this type of testing would be pipe and duct pressure testing, NETA testing and generator load bank testing. These tests are typically identified in the project specifications under Part 3. These activities should be scheduled with the General Contractor and included in the overall project schedule. The CxA will witness the test or review test reports from these activities.

BAS Integration Meeting

In order to assist in mitigating miscommunication from the design sequence of operations and the approved sequence of operations submittal, the CxA will meet with the designer, controls contractor and owner operations representative. This purpose of this meeting is to review that the design intent is met through the algorithms residing in the controllers, determine if the sequences match, are compatible with the functional performance test procedures to be written, and meet owner operational requirements. Often this detailed

review of the sequence of operation program will raise questions regarding the clarity and completeness of the approved sequence of operations and whether the actual process control program can implement the design intent. When these kinds of issues arise, they are documented in the CAL and RFIs are generally initiated which lead to project document changes being issued. These RFIs can be generated by the CxA or the controls contractor and are responded to by the designer.

After the meeting is completed and programming ensues, the controls subcontractor will begin to prove device control, calibration and accuracy. This activity is commonly referred to as "point to point" and is a key startup activity by the contractor.

BAS Point to Point

The BAS contractor shall perform point to point on all actuators, dampers, valves and verify calibration of sensors and meters. This process confirms that 1) all devices are properly wired, 2) what is required by the project has indeed been provided and 3) when the CxA performs the FPTs, all components will react as expected.

The BAS contractor will document the points on their own form and submit as part of the official project submission process. The point to point documentation is included with the PFC for the BAS or specific equipment PFC for CxA review and acceptance. Proving the analog or digital point operates as intended is crucial for proving the equipment or system will operate as intended and documented as per the sequence of operations.

Testing, Adjusting and Balancing

Once the BAS point to point is complete, the Testing, Adjusting, and Balancing (TAB) can begin. The TAB contractor will verify system air and water performance that is required by the project documents. The CxA will witness a sampling of the TAB activities during regular site observations or on random visits. These observations are to ensure that flow rates are adjusted to the design values and to verify the procedure used to balance the systems with diversity is adequately described. The CxA will review the TAB report as compiled by the contractor. It is preferred that the TAB contractor provide daily/weekly preliminary, hand written copies for the CxA to review as opposed to waiting for the report to be generated and submitted. Any comments will be directed to the GC and TAB contractor via the CAL.

The final TAB report shall be submitted as a standard submittal per the project requirements and the review process shall be as the other submittals.

Acceptance Phase

Task	Owner	Design Team	CxA	GC	Sub/Vendors
Commissioning Meetings	Attend	Attend	Host	Attend	Attend
Site Observations	Attend	--	Perform & Document	Coordinate	Support
Functional Performance Tests	Review & Comment	Review & Comment	Develop	Review & Comment	Review & Comment
Functional Test Review	Attend	Attend	Lead	Attend	Attend
Final Test Scheduling	Attend	--	Lead	Attend	Support
Functional Performance Testing	Attend	Support	Witness & Document	Coordinate	Support & Perform
Deficiencies, Re-testing and Acceptance	Support	Support	Witness & Document	Coordinate & Document	Perform & Document
Deficiencies (Cx Actions Log)	Support	Support	Witness & Document	Coordinate & Document	Perform & Document

Commissioning Meetings

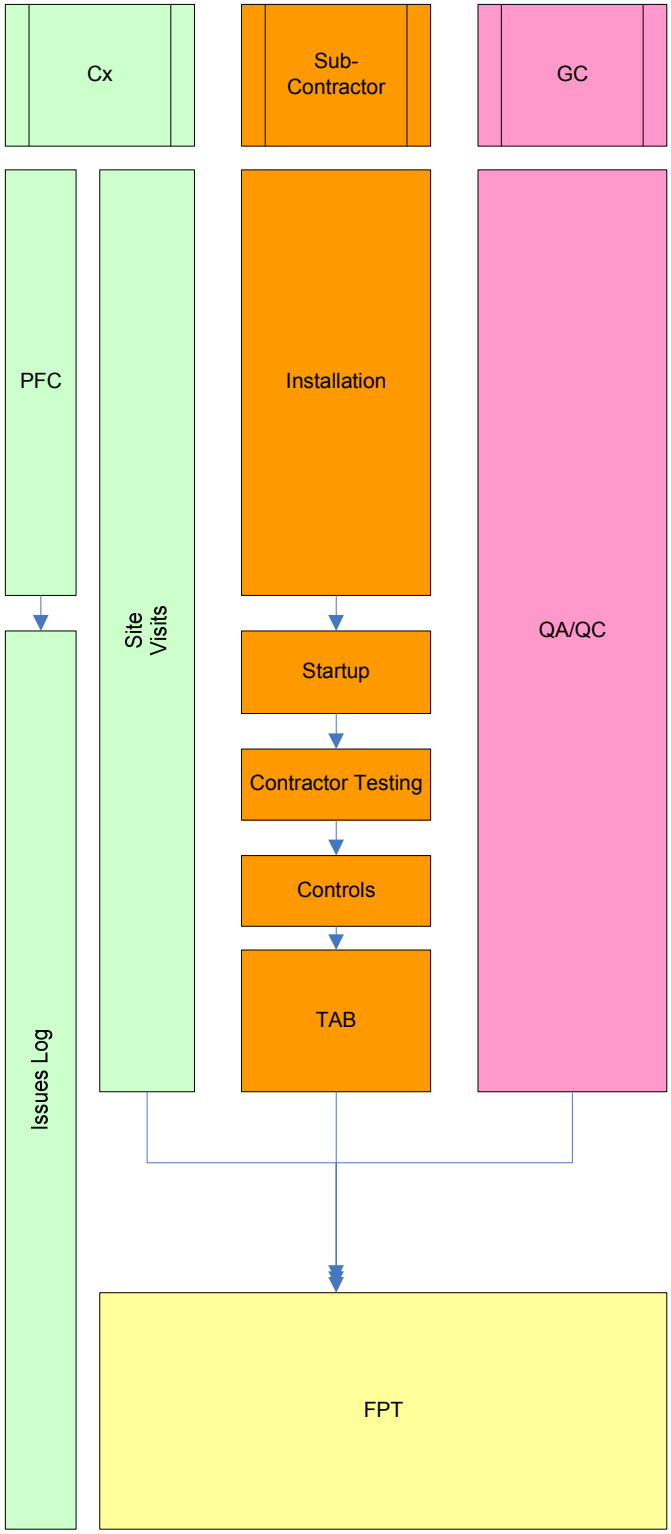
Commissioning meetings will be as described in above section.

Site observations

Site observations will be as described in above section.

Functional Performance Tests

Functional testing is the dynamic testing of equipment and systems under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation, and components are verified to be responding as the sequences state.



Before test procedures are written, the CxA obtains all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, control sequences, and setpoints. The CxA develops "Issued for Review" project, specific test procedures to verify proper operation of each piece of equipment and system to be commissioned. The CxA obtains clarification, as needed, from contractors and the A/E regarding sequences and operation to develop these tests.

Functional Performance Test Review

After all "Issued for Review" FPTs are developed, the CxA will submit them to the Cx Team for review and comment. During this period of time, the Cx Team shall confirm that the OPR, BOD, and approved submittals are being complied with and that the performing parties agree with what is required. During this review, comments are discussed and the CxA will incorporate all approved modifications to the FPTs. If any of the comments contradict current contract documents or submittals, those responsible parties shall update their documentation and submit via the approved chain of communication. The CxA will then submit to the Cx Team "Issued for Testing" version of the FPTs.

Final Test Scheduling

The CxA, Owner and GC/CM will review the current project schedule and modify any anticipated Commissioning milestone durations based on the actual 'Issued for Testing" FPTs that have been submitted. Additionally, all responsible parties required to participate in the FPTs will be identified in the project schedule and their presence will be confirmed.

For the equipment and systems that have BAS integration or control, the BAS contractor will be required to perform the FPTs on a sampling basis and document their results using the "Issued for Testing" FPTs. These tests along with current trends of the BAS points will be required to be submitted to the CxA for review PRIOR to the scheduling of FPTs.

Functional Performance Testing

The subcontractors and vendors execute the FPTs, while the Owner and CxA document the results. Functional testing may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend-logging capabilities. Standalone data loggers may also be utilized for supporting results documented. It is the intent of the project that when manual manipulation has occurred, that later trending or seasonal testing be performed to verify system performance in "automatic" mode per the sequence of operations.

Deficiencies, Re-testing, and Acceptance

Incomplete work or deficiencies discovered in PFCs, FPTs, or IS(O)Ts will be corrected by the responsible contractors and re-tested or witnessed to produce satisfactory results prior to proceeding to the next stage of the Commissioning process. The Contractor is responsible for deficient or incomplete work and will be responsible to ensure corrections necessary for full and complete system operation as specified are completed. One re-test for a given system or component will be performed within the scope of normal commissioning. **Additional re-tests required due to contractors not having the system or component functional for successful re-testing will result in charges to the contractors for additional re-testing time (beyond one re-test).**

Once all major deficiencies regarding equipment and system functionality are addressed, the CxA will recommend to the Owner that the building is ready for acceptance during the Final Sign-off Meeting. In accordance with the contract documents, acceptance of the building by the Owner typically initiates specified warranties. Commissioning clarifies requirements for initiation of the warranty period.

Commissioning Actions Log (CAL)

The CxA keeps a log of all commissioning-related issues that require current or future attention. The Commissioning Actions Log (CAL) provides a sortable form for tracking the status of all commissioning-related issues, including possible cause, recommendations, and action taken. As an item is identified, it is assigned to a responsible team member for championing its resolution. Through correspondence, such as Requests For Information (RFIs), emails, phone calls, site visits, etc., items will be

updated with status updates on an as-required basis, depending on the level of importance. Items that directly impact an activity or milestone will be required to be addressed sooner rather than later. Responsible team members may change as the item is updated and the CxA documents this evolution.

The CAL is not meant to be utilized as a "punch list" or deficiency report for action at the end of the project. For the Commissioning Process to be successful, the items on the CAL need to be addressed and removed as soon as possible with updates on progress made as requested. The CAL is one of the main agenda topics at the regularly held Commissioning Meetings.

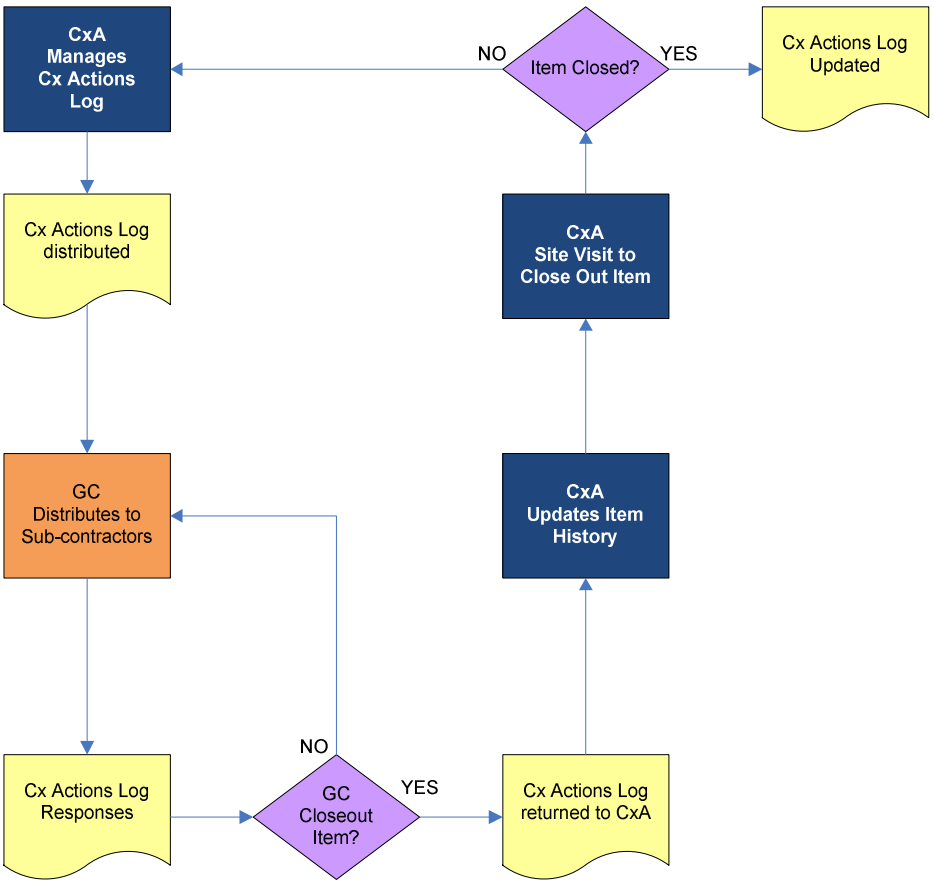


Diagram 2 - Actions Log Management Process

Occupancy Phase

Task	Owner	Design Team	CxA	GC	Sub/Vendors
O&M Manuals	Review & Comment	Approve	Review	Develop	Develop
Final Summary Report	Approve	--	Develop	--	--
Seasonal Testing	Coordinate & Attend	Support	Witness & Document	Coordinate	Support & Perform

Operations and Maintenance Manuals

O&M Manuals are prepared by the contractors for all maintainable equipment. They are organized by specification section as per the requirements of the Operations and Maintenance Manual's specification section.

Final Summary Report

A Final Summary report by the CxA will be provided to the Owner. This document summarizes the results of the commissioning process and discusses variances between design intent and the as-tested conditions and identifies any special operational or maintenance issues noted during commissioning. It also provides an evaluation of the systems operations and can serve as a future reference document during the operation of the facility systems.

The report may include, but is not limited to, the following:

I. Sections
   - A. Executive Summary
   - B. Commissioning Actions Log
   - C. Commissioning Plan
   - D. Commissioning Specs
   - E. Commissioning Field Reports and Meeting Minutes
   - F. Completed Pre-Functional Checklists
   - G. Blank Functional Performance Tests
   - H. Completed Functional Performance Tests

Seasonal Testing

The CxA coordinates, witnesses, and documents the completion of seasonal equipment and system testing by the contractors. The CxA works with the contractors in resolving issues identified during testing. The CxA incorporates comments into the Final Summary Report and provide a final copy to the Owner.

5.0 | Appendix

Example Commissioning Activities

Milestone	Sample Duration	Predecessor	Successor
Commissioning Kickoff Meeting	1 day	All contractors onboard including Controls and TAB	MEP Equipment Installation
Pre-Functional Checklist Coord. Mtg	1 Day	Develop PFCs	PFCs (at least 2 weeks after)
Develop System Functional Performance Tests	3 weeks	CD & Equipment submittal reviews & PFCs complete	TAB & FPT
Complete Pre-Functional Checklists	3 months	Equipment installation & startup is complete	TAB & FPT
Re-occurring Cx Coordination Meetings	1 day/Month	Pre-Functional Checklist Meeting	
Equipment Mfg Startup	3 weeks	PFC Acceptance	Controls, Contractor Testing
Control System Startup & Checkout	4 weeks	PFC Acceptance	TAB & Functional testing
Testing, Adjusting, & Balancing (TAB)	6 weeks	Controls Checkout, HVAC PFCs	Functional testing
Pre-FPT Meeting	1 day	TAB, Contractor Testing	FPT
Functional Performance Testing	3 months	TAB & all PFCs complete	Integrated Systems Test / Owner Acceptance
Final Operations & Maintenance Manuals Submission	1 week	Functional Testing	Operator Training
Systems Training Pre-Conference	1 day	Functional Testing	Training (at least 4 weeks after)
Systems Operations & Maintenance Training	2 weeks	Final O&M Delivery	Owner Acceptance

SECTION 03300 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

B. Related Requirements:

1. Section 02221 "Backfilling and Compacting for Structures and Pavements" in Site Work documents for structural fill under foundations and slabs-on-grade.
2. Section 02501 "Concrete Sidewalks, Aprons, and Stoops" in Site Work documents for concrete pavement and walks.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

   a. Subcontractor's superintendent.
   b. Independent testing agency responsible for concrete design mixtures.
   c. Ready-mix concrete manufacturer.
   d. Concrete Subcontractor.

2. Review special inspection and testing and inspecting agency procedures for field quality control, mass concrete mix design and placing procedures, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, methods for achieving specified floor and slab flatness and levelness floor and slab flatness and levelness measurement, and concrete protection.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Steel Reinforcement Shop Drawings: Placing Drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

D. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

1. Location of construction joints is subject to approval of the Architect.

E. Samples: For waterstops and vapor retarder.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Steel reinforcement and accessories.
4. Waterstops.
5. Curing compounds.
6. Floor and slab treatments.
7. Bonding agents.
8. Adhesives.
9. Vapor retarders.
10. Semirigid joint filler.
11. Joint-filler strips.
12. Repair materials.

C. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer, detailing fabrication, assembly, and support of formwork.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

D. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

E. Field quality-control reports.

F. Minutes of preinstallation conference.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician, Grade II.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

1.8 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

B. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. 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. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301.
2. ACI 117.

2.2 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

D. Form Ties: Factory-fabricated, removable or snap-off glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

C. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed bars, epoxy coated, with less than 2 percent damaged coating in each 12-inch bar length.

D. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, plain, fabricated from as-drawn steel wire into flat sheets.

E. Epoxy-Coated Welded-Wire Reinforcement: ASTM A 884/A 884M, Class A coated, Type 1, plain steel.

2.4 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

B. Epoxy-Coated Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, ASTM A 775/A 775M epoxy coated.

C. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.

D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

2.5 CONCRETE MATERIALS

A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

B. Cementitious Materials:

1. Portland Cement: ASTM C 150/C 150M, Type I/II, gray.
2. Fly Ash: ASTM C 618, Class F or C.

C. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

D. Air-Entraining Admixture: ASTM C 260/C 260M.

E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.

2. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

F. Water: ASTM C 94/C 94M and potable.

2.6 WATERSTOPS

A. Flexible Rubber Waterstops: CE CRD-C 513, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Profile: Ribbed with center bulb.
2. Dimensions: 9 inches by 3/8 inch thick; nontapered.

2.7 VAPOR RETARDERS

a. Sheet Vapor Retarder: ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive tape.

2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Fortifiber Building Systems Group.
b. Grace Construction Products; W.R. Grace & Co. -- Conn.
c. Insulation Solutions, Inc.
d. Poly-America, L.P.
e. Raven Industries, Inc.
f. Reef Industries, Inc.
g. Stego Industries, LLC.
h. Tex-Trude, Inc.
i. W.R. Meadows, Inc.

2.8 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. AWRC Corporation.
b. BASF Corporation-Construction Systems.
c. ChemMasters, Inc.

d. Dayton Superior.
e. Euclid Chemical Company (The); an RPM company.
f. Kaufman Products, Inc.
g. L&M Construction Chemicals, Inc.
h. Lambert Corporation.
i. Metalcrete Industries.
j. Right Pointe.
k. SpecChem, LLC.
l. TK Products.
m. Vexcon Chemicals Inc.
n. W.R. Meadows, Inc.

2.9 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 according to ASTM D 2240.

C. Bonding Agent: ASTM C 1059/C 1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Reglets: Fabricate reglets of not less than 0.022-inch-thick, galvanized-steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.

2.10 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150/C 150M, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.

1. Cement Binder: ASTM C 150/C 150M, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

2.11 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

2. Concrete placed in monolithic placements where the minimum of all three dimensions exceeds 3’-0” shall be considered “massive concrete” and shall be subject to the applicable requirements of ACI 301, Chapter 8. Use moderate or low heat of hydration cement, blended hydraulic cement with moderate or low heat of hydration properties, or portland cement with fly ash, pozzolan, or ground-granulated blast furnace slag. Approved retarding high-range water reducing, or retarding plasticizing admixture shall be used. Submit detailed procedures, materials, mix design, and test results including heat of hydration test data per ASTM C186 to Fermilab before construction of massive concrete.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash: 25 percent.

C. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

2.12 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Footings, Foundation Walls, Beams, Columns, and Piers: Normal-weight concrete.

1. Minimum Compressive Strength: 5000 psi at 28 days.
2. Maximum W/C Ratio: 0.45.

3. Slump Limit: 4 inches, or 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch.
4. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 3/4-inch nominal maximum aggregate size.

B. Slabs-on-Grade: Normal-weight concrete.

1. Minimum Compressive Strength: 4000 psi at 28 days.
2. Maximum W/C Ratio: 0.45.
3. Minimum Cementitious Materials Content: 540 lb/cu. yd..
4. Slump Limit: 4 inches, plus or minus 1 inch.
5. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

2.13 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.14 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1. When air temperature is between 85 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.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch for smooth-formed finished surfaces.
2. Class B, 1/4 inch for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Construct forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEM INSTALLATION

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.

3.3 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50

deg F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material are not acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 VAPOR-RETARDER INSTALLATION

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches and seal with manufacturer's recommended tape.

B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder according to manufacturer's written instructions.

3.5 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded-wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

F. Epoxy-Coated Reinforcement: Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M. Use epoxy-coated steel wire ties to fasten epoxy-coated steel reinforcement.

3.6 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. . Locate verticaljoints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
7. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
2. Sawed Joints: 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 does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Section 07 92 00 "Joint Sealants," are indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Doweled Joints: 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.

3.7 WATERSTOP INSTALLATION

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

3.8 CONCRETE PLACEMENT

A. Concrete placed in monolithic placements where the minimum of all three dimensions exceeds 3’-0” shall be considered “massive concrete” and shall be subject to the applicable requirements of ACI 301, Chapter 8. The maximum internal temperature during curing shall not exceed 160 degrees Fahrenheit. Submit detailed placement procedures to Fermilab before construction of massive concrete.

B. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections are completed.

C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Fermilab.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.

5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

3.9 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply the following to smooth-formed-finished as-cast concrete where indicated:

1. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix 1 part portland cement to 1-1/2 parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.10 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to surfaces to receive trowel finish andto be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of

trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces exposed to view orto be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
2. Finish surfaces to the following tolerances, according to ASTM E 1155, for a randomly trafficked floor surface:
   a. Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15; for slabs-on-grade.

D. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

3.11 MISCELLANEOUS CONCRETE ITEM INSTALLATION

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 6 inches high unless otherwise indicated, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
3. Minimum Compressive Strength: 5000 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel finish concrete surfaces.

3.12 CONCRETE PROTECTING AND CURING

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 ACI 301 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed 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. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for remainder of curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

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, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.

   a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
   b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
   c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies does not interfere with bonding of floor covering used on Project.

3. 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.

   a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound

manufacturer unless manufacturer certifies curing compound does not interfere with bonding of floor covering used on Project.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a 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. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.13 LIQUID FLOOR TREATMENT APPLICATION

A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
2. Do not apply to concrete that is less than 28 days' old.
3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

3.14 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least one month. Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.15 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension to solid concrete. Limit cut depth to 3/4 inch. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar matches surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.
3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Fermilab’s approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.16 FIELD QUALITY CONTROL

A. Special Inspections: Fermilab will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.

C. Inspections:

1. Steel reinforcement placement.
2. Verification of use of required design mixture.
3. Concrete placement, including conveying and depositing.
4. Curing procedures and maintenance of curing temperature.
5. Verification of concrete strength before removal of shores and forms from beams and slabs.

D. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.

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

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231/C 231M, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
5. Unit Weight: ASTM C 567/C 567M, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
6. Compression Test Specimens: ASTM C 31/C 31M.

   a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.

7. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
   a. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
9. Test results shall be reported in writing to Fermilab, concrete manufacturer, and Subcontractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
10. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Fermilab but will not be used as sole basis for approval or rejection of concrete.
11. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Fermilab. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Fermilab.
12. Additional testing and inspecting, at subcontractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
13. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

E. Measure floor and slab flatness and levelness according to ASTM E 1155 within 48 hours of finishing.

3.17 PROTECTION OF LIQUID FLOOR TREATMENTS

A. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION 03300

SECTION 04200 – Unit Masonry

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Concrete masonry units (CMUs).
2. Mortar and grout
3. Reinforcing steel
4. Masonry Joint reinforcement.
5. Ties and anchors.
6. Miscellaneous masonry accessories

1.02 ACTION SUBMITTALS

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

B. Shop Drawings: For reinforcing steel. Detail bending and placement of unit masonry reinforcing bars. Comply with ACI 315, "Details and Detailing of Concrete Reinforcement." Show elevations of reinforced walls.

1.03 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each type and size of product indicated. For masonry units include material test reports substantiating compliance with requirements.

B. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.

1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91 for air content.
2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.

1.04 QUALITY ASSURANCE

A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.

B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from a single manufacturer for each cementitious component and from one source or producer for each aggregate.

C. Masonry Standard: Comply with ACI 530.1/ASCE 6/TMS 602 unless modified by requirements in the Contract Documents.

D. Testing:

1. Masonry testing shall be performed by independent testing laboratory at Subcontractor's expense. Material and labor required to construct prisms and other test samples shall be provided by Subcontractor.

2. Subcontractor's testing agency shall issue monthly reports directly to the Owner for review.

3. Masonry shall be tested in accordance with section 1704.5.2 and Table 1704.5.1 of the 2009 International Building Code, and as set forth in ACI-530/ASCE6:

a) Level 1 Required Verification and Inspection of Masonry Construction:

TABLE 1704.5.1
LEVEL 1 REQUIRED VERIFICATION AND INSPECTION OF MASONRY CONSTRUCTION

VERIFICATION AND INSPECTION	FREQUENCY OF INSPECTION		REFERENCE FOR CRITERIA		
	CONTINUOUS	PERIODIC	IBC SECTION	TMS 402/ACI 530/ASCE 5[a]	TMS 602/ACI 530.1/ASCE 6[a]
1. Compliance with required inspection provisions of the construction documents and the approved submittals shall be verified.	—	X	—	—	Art. 1.5
2. Verification of f'_m and f'_{AAC} prior to construction except where specifically exempted by this code.		X	—	—	Art. 1.4B
3. Verification of slump flow and VSI as delivered to the site for self-consolidating grout.	X	—	—	—	Art. 1.5B.1.b.3
4. As masonry construction begins, the following shall be verified to ensure compliance:					
a. Proportions of site-prepared mortar.	—	X	—	—	Art. 2.6A
b. Construction of mortar joints.	—	X	—	—	Art. 3.3B
c. Location of reinforcement, connectors, prestressing tendons and anchorages.	—	X	—	—	Art. 3.4, 3.6A
d. Prestressing technique.	—	X	—	—	Art. 3.6B
e. Grade and size of prestressing tendons and anchorages.	—	X	—	—	Art. 2.4B, 2.4H
5. During construction the inspection program shall verify:					
a. Size and location of structural elements.	—	X	—	—	Art. 3.3F
b. Type, size and location of anchors, including other details of anchorage of masonry to structural members, frames or other construction.	—	X	—	Sec. 1.2.2(e), 1.16.1	—
c. Specified size, grade and type of reinforcement, anchor bolts, prestressing tendons and anchorages.	—	X	—	Sec. 1.15	Art. 2.4, 3.4
d. Welding of reinforcing bars.	X	—	—	Sec. 2.1.9.7.2, 3.3.3.4(b)	—
e. Preparation, construction and protection of masonry during cold weather (temperature below 40°F) or hot weather (temperature above 90°F).	—	X	Sec. 2104.3, 2104.4	—	Art. 1.8C, 1.8D
f. Application and measurement of prestressing force.	X	—	—	—	Art. 3.6B

TABLE 1704.5.1-continued
LEVEL 1 REQUIRED VERIFICATION AND INSPECTION OF MASONRY CONSTRUCTION

VERIFICATION AND INSPECTION	FREQUENCY OF INSPECTION		REFERENCE FOR CRITERIA		
	CONTINUOUS	PERIODIC	IBC SECTION	TMS 402/ACI 530/ASCE 5[a]	TMS 602/ACI 530.1/ASCE 6[a]
6. Prior to grouting, the following shall be verified to ensure compliance:					
a. Grout space is clean.	—	X	—	—	Art. 3.2D
b. Placement of reinforcement and connectors, and prestressing tendons and anchorages.	—	X	—	Sec. 1.13	Art. 3.4
c. Proportions of site-prepared grout and prestressing grout for bonded tendons.	—	X	—	—	Art. 2.6B
d. Construction of mortar joints.	—	X	—	—	Art. 3.3B
7. Grout placement shall be verified to ensure compliance:	X	—	—	—	Art. 3.5
a. Grouting of prestressing bonded tendons.	X	—	—	—	Art. 3.6C
8. Preparation of any required grout specimens, mortar specimens and/or prisms shal be observed.	—	X	Sec. 2105.2.2, 2105.3	—	Art. 1.4

1.05 PROJECT CONDITIONS

A. Protection of Masonry: During construction, cover top of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.

B. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

C. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

PART 2. PRODUCTS

2.01 MASONRY UNITS, GENERAL

A. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work.

B. Fire-Resistance Ratings: Where indicated, provide units that comply with requirements for fire-resistance ratings indicated as determined by testing according to ASTM E 119, by equivalent masonry thickness, or by other means, as acceptable to authorities having jurisdiction.

2.02 CONCRETE MASONRY UNITS

A. Shapes: Provide shapes indicated and for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.

B. Provide square-edged units for outside corners and at door jambs, unless otherwise indicated.

C. Integral Water Repellent: Provide units made with liquid polymeric, integral water repellent admixture that does not reduce flexural bond strength for exposed units and where indicated.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) ACM Chemistries, Inc.; RainBloc.

b) BASF Aktiengesellschaft; Rheopel Plus.

c) Grace Construction Products, W. R. Grace & Co. - Conn.; Dry-Block.

D. CMUs: ASTM C 90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 1900 psi unless noted otherwise on documents.

2. Density Classification: Normal weight unless otherwise indicated.

2.03 MASONRY LINTELS

A. General: Provide masonry lintels, complying with the following:

B. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs with reinforcing bars placed as indicated and filled with coarse grout.

2.04 MORTAR AND GROUT MATERIALS

A. Portland Cement: ASTM C 150, Type I or II, except Type III may be used for cold-weather construction. Provide natural color.

B. Hydrated Lime: ASTM C 207, Type S or N for interior work.

C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.

D. Masonry Cement: ASTM C 91.

E. Aggregate for Mortar: ASTM C 144.

1. For joints less than ¼" (6 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.

F. Aggregate for Grout: ASTM C 404.

G. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) Euclid Chemical Company (The); Accelguard 80.

b) Grace Construction Products, W. R. Grace & Co. - Conn.; Morset.

c) Sonneborn Products, BASF Aktiengesellschaft; Trimix-NCA.

H. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs, containing integral water repellent by same manufacturer.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a) ACM Chemistries, Inc.; RainBloc for Mortar.

b) BASF Aktiengesellschaft; Rheopel Mortar Admixture.

c) Grace Construction Products, W. R. Grace & Co. - Conn.; Dry-Block Mortar Admixture.

2. Water: Potable.

2.05 REINFORCEMENT

A. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, Grade 60.

B. Masonry Joint Reinforcement, General: ASTM A 951/A 951M.

1. Interior Walls: Hot-dip galvanized, carbon steel.

2. Exterior Walls: Hot-dip galvanized, carbon steel.

3. Wire Size for Side Rods: 0.148-inch diameter.

4. Wire Size for Cross Rods: 0.148-inch diameter.

5. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches o.c.

6. Provide in lengths of not less than 10 feet, with prefabricated corner and tee units.

2.06 TIES AND ANCHORS

A. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated.

1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M; with ASTM A 153/A 153M, Class B-2 coating.

2. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.

3. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

B. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch-diameter, hot-dip galvanized steel wire.

2. Tie Section: Triangular-shaped wire tie, sized to extend within 1 inch of masonry face, made from 0.187-inch diameter, hot-dip galvanized steel wire.

C. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Connector Section: Dovetail tabs for inserting into dovetail slots in concrete; formed from 0.060”-thick, steel sheet, galvanized after fabrication.

2. Tie Section: Triangular-shaped wire tie, sized to extend within 1 inch of masonry face, made from 0.187”-diameter, hot-dip galvanized steel wire.

D. Anchor Bolts: Headed or L-shaped steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers; hot-dip galvanized to comply with ASTM A 153/A 153M, Class C; of dimensions indicated.

2.07 MISCELLANEOUS MASONRY ACCESSORIES

A. Compressible Filler: Pre-molded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; formulated from neoprene.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated, organic roofing felt complying with ASTM D 226, Type I (No. 15 asphalt felt).

D. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells with loops for holding reinforcing bars in center of cells. Units are formed from 0.142” steel wire, hot-dip galvanized after fabrication. Provide units with either two loops or four loops as needed for number of bars indicated.

2.08 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

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

2. Use Portland cement-lime mortar unless otherwise indicated.

3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C 270, Property Specification. Provide type S mortar unless another type is indicated.

D. Grout for Unit Masonry: Furnish core fill grout ingredients in form of a preblended mix. Comply with ASTM C 476.

1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with Table 1.15.1in ACI 530.1/ASCE 6/TMS 602 for dimensions of grout spaces and pour height.

2. Proportion grout in accordance with ASTM C 476, paragraph 4.2.2 for specified 28-day compressive strength of not less than 2000 psi.

3. Provide grout with a slump of 8 to 11” as measured according to ASTM C 143/C 143M.

PART 3. EXECUTION

3.01 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation do not vary by more than plus ½” or minus ¼”.

2. For location of elements in plan do not vary from that indicated by more than plus or minus ½”.

3. For location of elements in elevation do not vary from that indicated by more than plus or minus 1/4 inch in a story height or ½” total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls do not vary from level by more than ¼” in 10’, or ½” maximum.

2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8” in 10’, ¼” in 20’, or ½” maximum.

3. For vertical lines and surfaces do not vary from plumb by more than ¼” inch in 10’, 3/8” in 20’, or ½” maximum.

4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8” in 10’, ¼” in 20’, or ½” maximum.

5. For lines and surfaces do not vary from straight by more than ¼” in 10’, 3/8” in 20’, or ½” maximum.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8” with a maximum thickness limited to ½”.

2. For head and collar joints, do not vary from thickness indicated by more than plus 3/8” or minus.

3. For exposed head joints, do not vary from thickness indicated by more than plus or minus.

3.02 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

C. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less than nominal 4” horizontal face dimensions at corners or jambs.

D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

E. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.

F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below and rod mortar or grout into core.

G. Fill cores in hollow CMUs with grout 24” under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.

H. Concrete/grout-fill 100 percent first course laid directly on concrete slabs.

3.03 MORTAR BEDDING AND JOINTING

A. Lay hollow CMUs as follows:

1. With face shells fully bedded in mortar and with head joints of depth equal to bed joints.

2. With webs fully bedded in mortar in all courses of piers, columns, and pilasters.

3. With webs fully bedded in mortar in grouted masonry, including starting course on footings.

4. With entire units, including areas under cells, fully bedded in mortar at starting course on footings where cells are not grouted.

B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

3.04 MASONRY JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8” on exterior side of walls, ½” elsewhere. Lap reinforcement a minimum of 6”.

1. Space reinforcement not more than 16” o.c. vertically.

2. Provide reinforcement not more than 8” above and below wall openings and extending 12” beyond openings in addition to continuous reinforcement.

B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

C. Provide continuity at wall intersections by using prefabricated T-shaped units.

D. Provide continuity at corners by using prefabricated L-shaped units.

3.05 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

A. Anchor masonry to structural steel and concrete where masonry abuts or faces structural steel or concrete to comply with the following:

1. Provide an open space not less than ½” wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.

2. Anchor masonry with anchors embedded in masonry joints and attached to structure where indicated.

3. Space anchors as indicated, but not more than 24” o.c. vertically and 36” o.c. horizontally.

3.06 REINFORCED UNIT MASONRY INSTALLATION

A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.

1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of

mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.

2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.

B. Placing Reinforcement: Comply with requirements in ACI 530.1/ASCE 6/TMS 602.

C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.

1. Comply with requirements in ACI 530.1/ASCE 6/TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.

2. Limit height of vertical grout pours to not more than 60”.

3.07 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas, as needed to perform tests and inspections. Retesting of materials that fail to meet specified requirements shall be done at Contractor’s expense.

B. Inspections: Level 1 special inspections according to the “International Building Code.”

1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.

2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.

3. Place grout only after inspectors have verified proportions of site-prepared grout.

C. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.

D. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.

E. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for compressive strength.

F. Grout Test (Compressive Strength): For each mix provided, according to ASTM C 1019.

3.08 REPAIRING, POINTING AND CLEANING

A. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

B. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Clean concrete masonry by cleaning method indicated in NCMA TEK 8-2A applicable to type of stain on exposed surfaces.

3.09 MASONRY WASTE DISPOSAL

A. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.

1. Do not dispose of masonry waste as fill within 18” of finished grade.

B. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above, and other masonry waste, and legally dispose of off Owner’s property.

END OF SECTION 04200

SECTION 05120 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structural steel.
2. Grout.

B. Related Requirements:
1. Section 05310 "Steel Decking" for field installation of shear connectors through deck.
2. Section 05500 "Metal Fabrications" for steel lintels and shelf angles not attached to structural-steel frame miscellaneous steel fabrications and other steel items not defined as structural steel.
3. Section 09900 "Painting and Coating" for surface-preparation and priming requirements.

1.2 DEFINITIONS

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication of structural-steel components.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Include embedment Drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts.

C. Delegated-Design Submittal: For structural-steel connections indicated to comply with design loads, include analysis data signed and sealed by the Structural Engineer licensed in the State of Illinois responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

D. Mill test reports for structural steel, including chemical and physical properties.

E. Product Test Reports: For the following:

1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
2. Direct-tension indicators.
3. Shop primers.
4. Nonshrink grout.

F. Survey of as-built cast-in anchor bolt installation.

G. Field quality-control and special inspection reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with applicable provisions of the following specifications and documents:

1. AISC 303.
2. AISC 341 and AISC 341s1.
3. AISC 360.
4. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
2. Clean and relubricate bolts and nuts that become dry or rusty before use.
3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering analysis by a licensed Structural Engineer, to withstand loads indicated and comply with other information and restrictions indicated.

1. Select and complete connections using schematic details indicated and AISC 360.
2. Use Allowable Stress Design; data are given at service-load level.

B. Moment Connections: Type FR, fully restrained.

C. Construction: Combined system of moment frame and braced frame] .

2.2 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A 992/A 992M.

B. Channels, Angles, M, S-Shapes: ASTM A 36/A 36M.

C. Plate and Bar: ASTM A 36/A 36M.

D. Cold-Formed Hollow Structural Sections: ASTM A 500/A 500M, Grade B, structural tubing.

E. Welding Electrodes: Comply with AWS requirements.

2.3 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers; all with plain finish.

1. Direct-Tension Indicators: ASTM F 959, Type 325, compressible-washer type with plain finish.

B. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex head assemblies consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.

1. Finish: Plain.

C. Headed Anchor Rods: ASTM F 1554, Grade 36, straight.

1. Nuts: ASTM A 563 heavy-hex carbon steel.
2. Plate Washers: ASTM A 36/A 36M carbon steel.
3. Washers: ASTM F 436, Type 1, hardened carbon steel.
4. Finish: Plain.

2.4 PRIMER

A. Primer: Comply with Section 09900 "Painting and Coating,"

B. Galvanizing Repair Paint: ASTM A 780/A 780M.

2.5 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.6 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.

1. Camber structural-steel members where indicated.
2. Fabricate beams with rolling camber up.
3. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
4. Mark and match-mark materials for field assembly.
5. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.

1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.

C. Bolt Holes: Cut, drill,or punch standard bolt holes perpendicular to metal surfaces.

D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 2, "Hand Tool Cleaning."

F. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural-steel frame. Straighten as required to provide uniform, square, and true members in completed wall framing. Build up welded framing, weld exposed joints continuously, and grind smooth.

G. Welded Door Frames: Build up welded door frames attached to structural-steel frame. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches o.c. unless otherwise indicated.

H. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.

1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.7 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Pretensioned.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.8 SHOP PRIMING

A. Shop prime steel surfaces except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
2. Surfaces to be field welded.
3. Surfaces of high-strength bolted, slip-critical connections.
4. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
5. Galvanized surfaces.
6. Surfaces enclosed in interior construction.

B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:

1. SSPC-SP 2, "Hand Tool Cleaning."

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

D. Painting: Prepare steel and apply a one-coat, nonasphaltic primer complying with SSPC-PS Guide 7.00, "Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems," to provide a dry film thickness of not less than 1.5 mils.

2.9 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/A 123M.

1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
2. Galvanize lintels shelf angles and welded door frames attached to structural-steel frame and located in exterior walls.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Fermilab will engage a qualified testing agency to perform shop tests and inspections.

1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.

B. Bolted Connections: Inspect shop-bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

C. Welded Connections: Visually inspect shop-welded connections according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

1. Liquid Penetrant Inspection: ASTM E 165.
2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
3. Ultrasonic Inspection: ASTM E 164.
4. Radiographic Inspection: ASTM E 94.

D. In addition to visual inspection, test and inspect shop-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:

1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
2. Conduct tests according to requirements in AWS D1.1/D1.1M on additional shear connectors if weld fracture occurs on shear connectors already tested.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Baseplates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate.
3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that are in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

E. Splice members only where indicated.

F. Do not use thermal cutting during erection.

G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Pretensioned.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
3. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," for mill material.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Fermilab will engage a qualified special inspector to perform the following special inspections:

1. Verify structural-steel materials and inspect steel frame joint details.
2. Verify weld materials and inspect welds.
3. Verify connection materials and inspect high-strength bolted connections.

B. Testing Agency: Fermilab will engage a qualified testing agency to perform tests and inspections.

C. Bolted Connections: Inspect bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

D. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M.

1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

a. Liquid Penetrant Inspection: ASTM E 165.
b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
c. Ultrasonic Inspection: ASTM E 164.

d. Radiographic Inspection: ASTM E 94.

3.6 REPAIRS AND PROTECTION

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair galvanizing to comply with ASTM A 780/A 780M.

B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 09900 “Painting and Coating”.

D. Touchup Priming: Cleaning and touchup priming are specified in Section 09900 “Painting and Coating”.

END OF SECTION 05120

SECTION 05210 - STEEL JOIST FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. LH-series long-span steel joists.
   2. Joist accessories.

1.2 DEFINITIONS

A. SJI's "Specifications": Steel Joist Institute's "Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders."

B. Special Joists: Steel joists or joist girders requiring modification by manufacturer to support nonuniform, unequal, or special loading conditions that invalidate load tables in SJI's "Specifications."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of joist, accessory, and product.

B. Shop Drawings:

   1. Include layout, designation, number, type, location, and spacing of joists.
   2. Include joining and anchorage details, bracing, bridging, and joist accessories; splice and connection locations and details; and attachments to other construction.
   3. Indicate locations and details of bearing plates to be embedded in other construction.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Welding certificates.

C. Manufacturer certificates.

D. Mill Certificates: For each type of bolt.

E. Comprehensive engineering analysis of special joists signed and sealed by the Structural Engineer licensed in the State of Illinois responsible for its preparation.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A manufacturer certified by SJI to manufacture joists complying with applicable standard specifications and load tables in SJI's "Specifications."

1. Manufacturer's responsibilities include providing professional structural engineering services for designing special joists to comply with performance requirements.

B. Welding Qualifications: Qualify field-welding procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle joists as recommended in SJI's "Specifications."

B. Protect joists from corrosion, deformation, and other damage during delivery, storage, and handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide special joists and connections capable of withstanding design loads indicated.

1. Use ASD; data are given at service-load level.
2. Design special joists to withstand design loads with live-load deflections no greater than the following:
   a. Roof Joists: Vertical deflection of 1/360 of the span.

2.2 LONG-SPAN STEEL JOISTS

A. Manufacture steel joists according to "Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series" in SJI's "Specifications," with steel-angle top- and bottom-chord members; of joist type and end and top-chord arrangements as indicated.

B. Provide holes in chord members for connecting and securing other construction to joists.

C. Camber long-span steel joists according to SJI's "Specifications.".

2.3 PRIMERS

A. Primer: SSPC-Paint 15, or manufacturer's standard shop primer complying with performance requirements in SSPC-Paint 15.

B. Primer: Provide shop primer that complies with Section 09900 "Painting and Coating".

2.4 JOIST ACCESSORIES

A. Bridging: Schematically indicated. Detail and fabricate according to SJI's "Specifications." Furnish additional erection bridging if required for stability.

B. Carbon-Steel Bolts and Threaded Fasteners: ASTM A 307, Grade A, carbon-steel, hex-head bolts and threaded fasteners; carbon-steel nuts; and flat, unhardened steel washers.

1. Finish: Plain, uncoated.

C. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.

1. Finish: Plain.

D. Welding Electrodes: Comply with AWS standards.

E. Furnish miscellaneous accessories including splice plates and bolts required by joist manufacturer to complete joist assembly.

2.5 CLEANING AND SHOP PAINTING

A. Clean and remove loose scale, heavy rust, and other foreign materials from fabricated joists and accessories by hand-tool cleaning, SSPC-SP 2 or power-tool cleaning, SSPC-SP 3.

B. Apply one coat of shop primer to joists and joist accessories to be primed to provide a continuous, dry paint film not less than 1 mil thick.

C. Shop priming of joists and joist accessories is specified in Section 09900 "Painting and Coating".

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting substrates, embedded bearing plates, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Do not install joists until supporting construction is in place and secured.

B. Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Specifications," joist manufacturer's written recommendations, and requirements in this Section.

1. Before installation, splice joists delivered to Project site in more than one piece.
2. Space, adjust, and align joists accurately in location before permanently fastening.
3. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.

C. Field weld joists to supporting steel framework. Coordinate welding sequence and procedure with placement of joists. Comply with AWS requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.

D. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Fermilab will engage a qualified independent testing and inspecting agency to inspect field welds and bolted connections and to perform field tests and inspections and prepare test and inspection reports.

B. Visually inspect field welds according to AWS D1.1/D1.1M.

1. In addition to visual inspection, test field welds according to AWS D1.1/D1.1M and the following procedures, as applicable:

a. Liquid Penetrant Inspection: ASTM E 165.
b. Magnetic Particle Inspection: ASTM E 709.
c. Ultrasonic Testing: ASTM E 164.
d. Radiographic Testing: ASTM E 94.

C. Visually inspect bolted connections.

D. Correct deficiencies in Work that test and inspection reports have indicated are not in compliance with specified requirements.

E. Perform additional testing to determine compliance of corrected Work with specified requirements.

3.4 PROTECTION

A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

B. Touchup Painting: After installation, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted joists abutting structural steel, and accessories.

1. Clean and prepare surfaces by hand-tool cleaning according to SSPC-SP 2, or power-tool cleaning according to SSPC-SP 3.
2. Apply a compatible primer of same type as primer used on adjacent surfaces.

C. Touchup Painting: Cleaning and touchup painting are specified in Section 09900 "Painting and Coating".

D. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that joists and accessories are without damage or deterioration at time of Substantial Completion.

END OF SECTION 05210

SECTION 05310 - STEEL DECKING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof deck.

B. Related Requirements:
1. Section 05500 "Metal Fabrications" for framing deck openings with miscellaneous steel shapes.
2. Section 09900 "Painting and Coating" for repair painting of primed deck and finish painting of deck.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of deck, accessory, and product indicated.

B. Shop Drawings:

1. Include layout and types of deck panels, anchorage details, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of steel deck.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that each of the following complies with requirements:

1. Power-actuated mechanical fasteners.

D. Evaluation Reports: For steel deck.

E. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.3, "Structural Welding Code - Sheet Steel."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

B. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.2 ROOF DECK

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:Canam Steel Corporation; Canam Group, Inc.
2. Epic Metals Corporation.
3. New Millennium Building Systems, LLC.
4. Nucor Corp.
5. Verco Decking, Inc., a Nucor company.

B. Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with "SDI Specifications and Commentary for Steel Roof Deck," in SDI Publication No. 31, and with the following:
1. Galvanized and Shop-Primed Steel Sheet: ASTM A 653/A 653M, Structural Steel (SS), Grade 33, G60 zinc coating; cleaned, pretreated, and primed bottom surface with manufacturer's standard baked-on, rust-inhibitive primer.

a. Color: Manufacturer's standard
2. Deck Profile: As indicated.
3. Profile Depth: As indicated.
4. Design Uncoated-Steel Thickness: As indicated.

5. Span Condition: As indicated.
6. Side Laps: Overlapped or interlocking seam at Contractor's option.

2.3 ACCESSORIES

A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.

B. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.

C. Side-Lap Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 10 minimum diameter.

D. Flexible Closure Strips: Vulcanized, closed-cell, synthetic rubber.

E. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi, not less than 0.0359-inch design uncoated thickness, of same material and finish as deck; of profile indicated or required for application.

F. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck unless otherwise indicated.

G. Weld Washers: Uncoated steel sheet, shaped to fit deck rib, 0.0598 inch thick, with factory-punched hole of 3/8-inch minimum diameter.

H. Flat Sump Plates: Single-piece steel sheet, 0.0747 inch thick, of same material and finish as deck. For drains, cut holes in the field.

I. Recessed Sump Pans: Single-piece steel sheet, 0.0747 inch thick, of same material and finish as deck, with 3-inch- wide flanges and [level] [sloped] recessed pans of 1-1/2-inch minimum depth. For drains, cut holes in the field.

J. Galvanizing Repair Paint: [ASTM A 780] [SSPC-Paint 20 or MIL-P-21035B, with dry film containing a minimum of 94 percent zinc dust by weight].

K. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install deck panels and accessories according to applicable specifications and commentary in SDI Publication No. 31, manufacturer's written instructions, and requirements in this Section.

B. Install temporary shoring before placing deck panels if required to meet deflection limitations.

C. Locate deck bundles to prevent overloading of supporting members.

D. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.

1. Align cellular deck panels over full length of cell runs and align cells at ends of abutting panels.

E. Place deck panels flat and square and fasten to supporting frame without warp or deflection.

F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.

G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.

H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.

I. Mechanical fasteners may be used in lieu of welding to fasten deck. Locate mechanical fasteners and install according to deck manufacturer's written instructions.

3.3 ROOF-DECK INSTALLATION

A. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1-1/2 inches long, and as follows:

1. Weld Diameter: 5/8 inch, nominal.
2. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds 12 inches apart.
3. Weld Washers: Install weld washers at each weld location.

B. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals not exceeding the lesser of 1/2 of the span or 36 inches, and as follows:

1. Mechanically fasten with self-drilling, No. 10 diameter or larger, carbon-steel screws.

C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches, with end joints as follows:

1. End Joints: Lapped 2 inches minimum or butted at Contractor's option.

D. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and weld flanges to top of deck. Space welds not more than 12 inches apart with at least one weld at each corner.

1. Install reinforcing channels or zees in ribs to span between supports and weld.

E. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer's written instructions. Weld to substrate to provide a complete deck installation.

1. Weld cover plates at changes in direction of roof-deck panels unless otherwise indicated.

F. Flexible Closure Strips: Install flexible closure strips over partitions, walls, and where indicated. Install with adhesive according to manufacturer's written instructions to ensure complete closure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Fermilab will engage a qualified testing agency to perform tests and inspections.

B. Field welds will be subject to inspection.

C. Testing agency will report inspection results promptly and in writing to Subcontractor and Fermilab.

D. Remove and replace work that does not comply with specified requirements.

E. Additional inspecting, at Subcontractor's expense, will be performed to determine compliance of corrected work with specified requirements.

3.5 PROTECTION

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.

B. Repair Painting: Wire brush and clean rust spots, welds, and abraded areas on both surfaces of prime-painted deck immediately after installation, and apply repair paint.

1. Apply repair paint, of same color as adjacent shop-primed deck, to bottom surfaces of deck exposed to view.
2. Wire brushing, cleaning, and repair painting of bottom deck surfaces are included in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

C. Repair Painting: Wire brushing, cleaning, and repair painting of rust spots, welds, and abraded areas of both deck surfaces are included in Section 09900 "Painting and Coating".

D. Provide final protection and maintain conditions to ensure that steel deck is without damage or deterioration at time of Substantial Completion.

END OF SECTION 05310

SECTION 05500-METAL FABRICATIONS

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Extent of metal fabrications work is shown on the drawings and includes items fabricated from steel shapes, plates, bars, strips, tubes, pipes and castings which are not part of the structural steel or other metal systems in other sections of these specifications.

B. Metal fabrications items include, but are not limited to the following:

1. Bolts, anchors and fasteners.
2. Carpenter's iron work.
3. Miscellaneous framing and supports.
4. Miscellaneous steel trim.
5. Metal ladders and ladder safety cages.
6. Shaft and Hatch covers.
7. Steel framed canopy.
8. Track plates, pull plates and setting grout.
9. Embedded steel shapes and headed stud anchors.
10. Embedded Channel Inserts.
11. Carbon Steel buried air ducts.

1.02 REFERENCE TO STANDARDS

A. ASTM A36 - Structural Steel.

B. ASTM A53 - Hot-Dipped, Zinc-coated Welded and Seamless Steel Pipe.

C. ASTM A123 - Zinc (Hot-Galvanized) Coatings on Products Fabricated From Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip.

D. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

E. ASTM A786 – Hot Rolled Steel Floor Plate.

F. ASTM A193 - Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure and Other Special Purpose Applications.

G. ASTM A307 - Carbon Steel Externally Threaded Standard Fasteners.

H. ASTM A325 - High Strength Bolts for Structural Steel Joints.

I. ASTM A386 - Zinc-Coating (Hot-Dip) on Assembled Steel Products.

J. ASTM A500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Round and Shapes.

K. AWS A2.0 - Standard Welding Symbols.

L. AWS D1.1 - Structural Welding Code.

M. SSPC - Steel Structures Painting Council.

N. AISI 304 - Stainless Steel Fasteners, Nuts and Washers.

1.03 SUBMITTALS

A. Submit under the provisions of Exhibit A, Section 12.0 - Submittals, Shop Drawings and Material Samples.

B. Submit shop drawings for fabrication and erection of miscellaneous metal assemblies. Show anchorage and accessory items. Provide templates for anchor and bolt installation by others.

C. Indicate welded connections using standard AWS A2.0 welding symbols. Indicate net weld strengths.

D. Product Data: Submit manufacturer's specifications, anchor details and installation instructions for products to be used in fabrication of miscellaneous metal work, including paint products. Indicate by transmittal that copy of instructions has been distributed to installer.

1.04 QUALITY ASSURANCE

A. Field Measurements:

1. Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting wherever taking field measurements before fabrication might delay work.

B. Inserts and Anchorages:

1. Furnish inserts and anchoring devices which must be set in concrete or built into masonry for installation of metal work. Provide setting drawings, templates, instructions and directions for installation of anchorage devices. Coordinate delivery with other work to avoid delay.

2. See concrete, mechanical, electrical and other sections of these specifications for installation of inserts and anchorage devices.

C. Shop Assembly:

1. Pre-assemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary to shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

D. Codes and Standards:

1. Comply with the provisions of the following codes, standards and specifications, except as otherwise shown and specified:

a) AISC – “Specification for Structural Steel Buildings” (ANSI/AISI 360-05), and including “Commentary on the Specification for Structural Steel Buildings.”

b) AISI - “Specification for the Design of Cold-Formed Steel Structural Members.”

c) AWS - “Code for Welding in Building Construction.”

d) ASTM A6 - “General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use.”

E. AISC Qualification for Welding Work:

1. Qualify welding processes and welding operators in accordance with AWS “Standard Qualification Procedure.”

PART 2. PRODUCTS

2.01 MATERIALS

A. Steel Plates, Shapes and Bars: ASTM A36.

B. Steel Tubing (HSS Sections): ASTM A500, Grade B.

C. Pipe: ASTM A53, Grade B, Type S, Schedule 40 (Exterior).

D. Pipe: ASTM A53, Grade B, Type S. Schedule 80 (Interior).

E. Fasteners: ASTM A307, unless noted otherwise.

F. Threaded bars and accessories anchors for embedded channels shall be the Threadbar Reinforcing Systems as manufactured by Dywidag Systems International or approved equal, Grade 60 KSI.

G. Embedded channel Inserts, Unistrut Corporation’s 3200 Series, pre galvanized conforming to ASTM A653 GR 33, with closure strip, and end plates or approved equal.

H. Bolts, Nuts, and Washers: ASTM A307, unless noted otherwise.

I. High-Strength Threaded Fasteners: ASTM A325, ¾” diameter (minimum), unless noted otherwise.

J. Welding Materials: AWS D1.1; type required for materials being welded.

K. Touch-Up Paint: ZRC Galvalite Cold Galvanizing Compound, or equal.

L. Bitumastic Paint for all steel elements below grade and exposed to earth shall be Carboline Bitumastic 50 or approved equal.

M. Cathartic protection: all steel element below grade, and exposed to earth, shall have a minimum 17 pounds anode affixed to the buried steel or as specified in specification section 02510, Utilities, Part 2, 2.01G.

N. Drilled-In Anchors:

1. All drilled-in concrete anchors shall be adhesive capsule anchor type or expansion anchor type, as manufactured by Hilti, or approved equal. Use of expansion anchor devices shall be permitted only where shown on the drawings and where required for attachment of miscellaneous equipment. There will be no exceptions to this requirement. Drilled-in anchors shall be a minimum of ½” diameter, unless noted otherwise, with minimum embedment as required by manufacturer, or shown on the drawings.

O. Grating over base slab trenches shall be Aluminum Plank Grate, unpunched, 2 ½” deep by 6” wide, Heavy Duty-Plain Sides as manufactured by Interstate Grating or approved equal.

2.02 FASTENERS

A. General:

1. Provide zinc-coated fasteners for exterior use or where built into exterior walls. Select fasteners for type, grade and class required. Stainless steel fasteners shall be used where exposed to earth.

B. Bolts and Nuts:

1. Regular hexagon head type, ASTM A307, Grade A or ASTM A325 bolts.

2. Regular hexagon or square type, ASTM A563 nuts.

C. Lag Bolts:

1. Square head type, FS FF-B-561.

D. Machine Screws:

1. Cadmium plated steel, FS-FF-S-92.

E. Wood Screws:

1. Flat head carbon steel, FS-FF-S-111.

F. Plain Washers:

1. Round, carbon steel, FS FF-W-92.

G. Lock Washers:

1. Helical spring type carbon steel, FS FF-W-84.

2.03 FINISH

A. All steel shapes, plates, bars, strips and assemblies shall be primed and painted with two finish coats.

B. Structural steel, joists and miscellaneous steel:

1. Prior to delivery and erection abrasive blast in accordance with SSPC-SP6. Blast profile shall be compatible with primer paint.

2. Immediately after blasting (same day) paint with prime coat as indicated.

2.04 FABRICATION - GENERAL

A. Workmanship:

1. Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability in finished product. Work to dimensions shown or accepted on shop drawings, using proven details of fabrication and support. Use type of materials shown or specified for various components of work.

2. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1/32” unless otherwise shown. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

3. Weld corners and seams continuously, complying with AWS recommendations. Grind exposed welds smooth and flush, to match and blend with adjoining surfaces. All welds shall be made with E70XX electrodes and shall conform to AWS Specifications.

4. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of type shown or, if not shown, Phillips flat-head (countersunk) screws or bolts.

5. Provide for anchorage of type shown, coordinated with supporting structure. Fabricate and space anchoring devices as shown and as required to provide adequate support for intended use.

6. Cut, reinforce, drill and tap miscellaneous metal work as required to provide adequate support for intended use.

7. Cut, reinforce, drill and tap miscellaneous metal work as required to receive finish hardware and similar items.

8. Use hot-rolled steel bars for work fabricated from bar stock, unless shown or specified to be fabricated from cold-finished or cold-rolled stock.

9. Verify dimensions on site prior to shop fabrication.

10. Fabricate items with joints tightly fitted and secured.

11. Fit and shop assemble in largest practical sections, for delivery to site.

12. Grind exposed welds flush and smooth with adjacent finished surface. Ease exposed edges to small uniform radius.

13. Exposed Mechanical Fastenings: Flush countersunk screws or bolts; unobtrusively located; consistent with design of structure, except where specifically noted otherwise.

14. Supply components required for anchorage of metal fabrications. Fabricate anchorage and related components of same material and finish as metal fabrication, except where specifically noted otherwise.

15. Paint Primer - Provide shop applied prime coat in accordance with Section 09900 - Painting.

2.05 STEEL LADDERS AND CAGES:

A. Comply with ANSI A14.3, unless otherwise indicated.

B. Space siderails 18” apart, unless otherwise indicated.

C. Support each ladder at top and bottom and not more than 48” o.c. with welded or bolted brackets, made from same metal as ladder.

D. Siderails: Continuous, ½” x 2 ½ ” steel flat bars, with eased edges.

E. Rungs: 1” diameter steel bars

F. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.

G. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.

H. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically boned to rung by a proprietary process.

I. Galvanize exterior, including brackets and fasteners.

2.06 MISCELLANEOUS METAL ITEMS

A. Carpenter's Iron Work:

1. Furnish bent or otherwise custom fabricated bolts, plates, anchors, hangers, dowels and other miscellaneous steel and iron shapes as required for framing and supporting woodwork and for anchoring or securing woodwork to concrete or other structures. Straight bolts and other stock rough hardware are specified in Division 6 Sections.

2. Manufacture or fabricate items of sizes, shapes and dimensions required. Furnish malleable iron washers for heads and nuts which bear on wood structural connections; elsewhere, furnish steel washers.

B. Miscellaneous Steel Trim:

1. Provide shapes and sizes as required for profiles shown. Except as otherwise noted, fabricate units from structural steel shapes and plates and steel bars, with continuously welded joints and smooth exposed edges. Use concealed field splices wherever possible. Provide cutouts, fittings and anchorages as required for coordination of assembly and installation with other work:

a) Galvanize miscellaneous steel trim where indicated.

2.07 ANCHOR BOLTS AND ADHESIVE ANCHORS

A. All steel anchor bolts shall be as detailed on the plans and shall be ASTM A 1554 Gr. 36, with hardened washers and standard nuts, all shall be Hot Dip Galvanized.

B. All adhesive anchors in exposed and/or exterior conditions shall consist of Type 304 stainless steel rods and an adhesive cartridge. All other adhesive anchors shall consist of A193 rods and an adhesive cartridge. All adhesive anchors shall be Hilti HAS Anchor Rod Assembly with Hilti HBP Adhesive Cartridge, EPCON Epoxy Anchoring System from ITW, or equal. Expansion anchors will not be permitted under any circumstance where adhesive anchors are indicated.

2.08 TRACK AND PULL PLATES

A. Plates shall conform to ASTM A36.

B. Tolerances: the track plates and pull plates shall be furnished with a flatness tolerance of .125" over a 12' length. If necessary, a press shall be used to achieve this flatness. Matching ends of plates are to be parallel and perpendicular to the length of the plate. If required, mill the ends of the plates to achieve this squareness. If the plates are bowed, fabricate with the bow up.

C. Fill all of the holes, except the grout holes, with cosmoline grease and cover with a 1/8” cap plate before shipping.

2.09 GROUT FOR TRACK AND PULL PLATES

A. Grout shall be a non-shrink/non-bleed grout. Grout shall have a minimum 28 day compressive strength of 7000 psi with a flow cone consistency of 25 seconds ± 5 seconds. Acceptable grouts are “Crystex” by L&M Construction Chemicals, Masterflow 928 by Master Builders or an approved equal.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.

B. Beginning of installation means erector accepts existing conditions.

3.02 PREPARATION

A. Furnish setting drawings, diagrams, templates, instructions and directions for installation of anchorages, such as concrete inserts, anchor bolts and miscellaneous items having integral anchors, which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to project site.

B. Obtain Construction Coordinator approval prior to site cutting or making adjustments not scheduled.

C. Clean and strip steel items to bare metal where site welding is scheduled.

D. Make provisions for erection loads with temporary bracing. Keep work in alignment.

E. Supply items required to be cast into concrete or embedded in masonry with setting templates, to appropriate sections.

3.03 INSTALLATION

A. Fastening to In-Place Construction:

1. Provide anchorage devices and fasteners where necessary for securing miscellaneous metal items to in-place construction; including threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws and other connectors as required.

B. Cutting, Fitting and Placement:

1. Perform cutting, drilling and fitting required for installation of miscellaneous metal items. Set work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Provide temporary bracing or anchors in

formwork for items which are to be built into concrete, masonry or similar construction.

C. Fit exposed connections accurately together to form tight hairline joints. Weld connections which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations. Grind joints smooth and touch-up shop paint coat or galvanized finish.

D. Allow for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

E. Field weld components indicated on Drawings.

F. Embedded channel inserts shall be set flush with concrete face and shall be free of concrete and debris including any nails used to attach to forms.

G. Perform field welding in accordance with AWS D1.1.

H. Obtain Construction Coordinator approval prior to site cutting or making adjustments not scheduled.

I. Immediately after erection, clean field welds, bolted connections and abraded areas and touch up with 6 mils of cold galvanizing compound.

3.04 ERECTION TOLERANCES

A. Deviation from plumb, level and alignment shall not exceed one (1) in five hundred (500).

3.05 TRACK AND PULL PLATES

3.06 A. PLANNING: Submit a written work plan with the steel plate submittal which outlines the plate selection, fabrication, installation, welding, survey, leveling and grouting procedures.

B. Carefully align and level the top surface of the track and pull plates at the joints to ± 1/16” of the elevation shown on the drawings. Scribe the plates for proper alignment.

C. The accumulation of the mill tolerances and the fabrication tolerances shall not cause the erection tolerances to be exceeded. Erection tolerances for the plates are plus or minus 3/16” to the established grade and plus or minus 1/8” to the prescribed line based on the plate centerline.

D. Grouting Instructions:

I. Surface preparations: Clean surfaces of oil, grease, dirt and mechanically roughen the concrete surface removing the laitance down to sound concrete in the area to be grouted. Abrasive blast the steel plates to commercial grade SP-6 and coat with a lead and chromate free rust-inhibitive clear

epoxy paint or primer. Saturate the clean surfaces with water. Remove all standing water prior to grouting.

II. Forms: to facilitate continuous and complete filling of space, forms must be strong and tight to prevent leaking. Maintain full contact of grout with plate and base mat until it hardens.

III. Mixing: Set up mixing adjacent to grouting area. Grout shall be mixed in a mixer to a smooth consistency. Placing of the grout shall be done by a grout pump or damp packing.

IV. Temperature: Avoid storing grout in extreme temperature areas; i.e., warm storage in cold weather and cool storage in hot weather. Mixing and placing is to be done in the 45° F to 70° F temperature range. Keep base mat, plates and grout above 40° F for at least 24 hours after placement.

V. Curing: Cover all exposed grout with wet rags immediately after placing.

VI. Precautions: Grout is cement based. Follow ACI practices for storing, mixing, placing and curing concrete in hot or cold weather. Do not add cement or plasticizer to grout. Avoid mixing more grout than can be placed within manufacturer's recommended time. Avoid grout placement when temperatures are or will be below 40° F (4° C) within 24 hours. Rapid and continuous mixing and placing are necessary on large pours. Avoid excessive vibration of plates at time of placement and for a period of 48 hours. It is the Subcontractor's responsibility to follow the recommendations of the manufacturer to insure a proper job.

END OF SECTION 05500

SECTION 05510 - METAL STAIRS

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Preassembled steel stairs with concrete-filled treads

2. Steel tube railings attached to metal stairs.

3. Steel tube handrails attached to walls adjacent to metal stairs.

B. See Section 05521 “Pipe and Tube Railings” for pipe and tube railings not attached to metal stairs or to walls adjacent to metal stairs.

1.02 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design metal stairs, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance of Stairs: Metal stairs shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.

1. Uniform Load: 100 lbf/sq. ft

2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.

3. Uniform and concentrated loads need not be assumed to act concurrently.

4. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.

5. Limit deflection of treads, platforms, and framing members to L/240 or ¼”, whichever is less.

C. Structural Performance of Railings: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.

1. Handrails and Top Rails of Guards:

a) Uniform load of 50 lbf/ ft. applied in any direction.

b) Concentrated load of 200 lbf applied in any direction.

c) Uniform and concentrated loads need not be assumed to act concurrently.

2. Infill of Guards:

a) Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft.

b) Infill load and other loads need not be assumed to act concurrently.

1.03 ACTION SUBMITTALS

A. Product Data: For metal stairs and the following:

1. Concrete filled metal-pan stair treads

2. Abrasive nosings

3. Paint products

B. Welding certificates.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified structural engineer responsible for their preparation. Stair designer shall be a licensed Structural Engineer licensed in the state of Illinois.

1.04 QUALITY ASSURANCE

A. NAAMM Stair Standard: Comply with “Recommended Voluntary Minimum Standards for Fixed Metal Stairs” in NAAMM AMP 510, “Metal Stairs Manual,” for class of stair designated, unless more stringent requirements are indicated.

1. Preassembled Stairs: Service class.

PART 2. PRODUCTS

2.01 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Steel Tubing: ASTM A 500 (cold formed) or ASTM A 513.

D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.

E. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

F. Uncoated, Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, either commercial steel, Type B, or structural steel, Grade 30, unless another grade is required by design loads.

2.02 ABRASIVE NOSINGS

A. Extruded Units: Aluminum units with abrasive filler in an epoxy-resin binder.

1. Basis of Design Product: Subject to compliance with requirements, provide Supergrit Profile type 121BF (1-7/8” wide) safety treads/nosings as manufactured by Wooster Products Inc. or comparable product by one of the following:

   a) American Safety Tread Co., Inc.

   b) Balco Inc.

   c) Granite State Casting Co.

   d) Safe-T-Metal Company, Inc.

2. Provide ribbed units, with abrasive filler strips projecting 1/16” above aluminum extrusion.

3. Provide solid-abrasive-type units without ribs.

B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

C. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.

D. Apply clear lacquer to concealed surfaces of extruded units set into concrete.

2.03 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, struts, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.

1. Join components by welding unless otherwise indicated.

2. Use connections that maintain structural value of joined pieces.

B. Preassembled Stairs: Assemble stairs in shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges. Remove sharp or rough areas on exposed surfaces.

D. Form bent-metal corners to smallest radius possible without impairing work.

E. Weld connections to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Weld exposed corners and seams continuously unless otherwise indicated.

5. At exposed connections, finish exposed welds to comply with NOMA's "Voluntary Joint Finish Standards" for 2 welds: completely sanded joint, some undercutting and pinholes okay.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Locate joints where least conspicuous.

G. Fabricate joints that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.04 STEEL-FRAMED STAIRS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alfab, Inc.

2. American Stair, Inc.

3. Sharon Companies Ltd. (The).

B. Stair Framing:

1. Fabricate stringers of steel plates or channels.

2. Construct platforms of steel plate or channel headers and miscellaneous framing members as needed to comply with performance requirements.

3. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.

4. Where stairs are enclosed by gypsum board or shaft-wall assemblies, provide hanger rods or struts to support landings from floor construction above or below.

5. Where stairs are enclosed by masonry walls, provide hanger rods or struts to support landings from floor construction or steel framing members above or below.

6. Where masonry walls support metal stairs, provide temporary supporting struts designed for erecting steel stair components before installing masonry.

7. Provide stair assemblies with metal-pan subtreads filled with reinforced concrete during fabrication.

2.05 STAIR RAILINGS

A. Steel Tube Railings: Fabricate railings to comply with requirements indicated for design, dimensions, details, finish, and member sizes, including wall thickness of tube, post spacings, and anchorage, but not less than that needed to withstand indicated loads.

1. Rails and Posts: 1-½” outside-diameter top and bottom rails and 1-½”-outside-diameter posts.

2. Picket Infill: As indicated on the drawings spaced less than 4” clear.

3. Intermediate Rails Infill: 1-½”-outside-diameter intermediate rails spaced less than 21” clear.

B. Welded Connections: Fabricate railings with welded connections. Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Finish welds to comply with NOMA's "Voluntary Joint Finish Standards" for Type 2 welds: completely sanded joint, some undercutting and pinholes okay, grind all welds smooth.

C. Form changes in direction of railings by bending or by inserting prefabricated elbow fittings.

D. Form curves by bending members in jigs to produce uniform curvature without buckling.

E. Close exposed ends of railing members with prefabricated end fittings.

F. Provide wall returns at ends of wall-mounted handrails.

G. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting components and for attaching to other work.

1. Connect posts to stair framing by direct welding.

2.06 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish metal stairs after assembly.

C. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

D. Apply shop primer to uncoated surfaces of metal stair components. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

E. Stairs and railings to be field painted in accordance with Section 9900.

PART 3. EXECUTION

3.01 INSTALLATION

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication.

C. Field Welding: Comply with requirements for welding in “Fabrication, General” Article.

D. Place and finish concrete fill for treads and platforms to comply with Section 033000 “Cast-in-Place Concrete.”

1. Install abrasive nosings with anchors fully embedded in concrete.

E. Attach handrails to wall with wall brackets. Use type of bracket with predrilled hole for exposed bolt anchorage.

3.02 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

END OF SECTION 05510

SECTION 05521 - PIPE AND TUBE RAILINGS

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Steel pipe and tube railings for elevated walkway areas and where indicated on plans.

2. Wall mounted handrail for concrete stairs

B. Related Sections include the following:

1. Division 5 Section “Metal Stairs” for steel tube railings associated with metal stairs.

1.02 PERFORMANCE REQUIREMENTS

A. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:

1. Steel: 72 percent of minimum yield strength.

B. Structural Performance: Provide railings capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Handrails:

a) Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.

b) Concentrated load of 200 lbf (0.89 kN) applied in any direction.

c) Uniform and concentrated loads need not be assumed to act concurrently.

2. Top Rails of Guards:

a) Uniform load of 50 lbf/ ft. (0.73 kN/m) applied horizontally and concurrently with 100 lbf/ ft. (1.46 kN/m) applied vertically downward.

b) Concentrated load of 200 lbf (0.89 kN) applied in any direction.

c) Uniform and concentrated loads need not be assumed to act concurrently.

3. Infill of Guards:

a) Concentrated load of 200 lbf (0.89 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).

b) Uniform load of 25 lbf/sq. ft. (1.2 kN/sq. m) applied horizontally.

c) Infill load and other loads need not be assumed to act concurrently.

C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.03 SUBMITTALS

A. Product Data: For the following:

1. Manufacturer's product lines of mechanically connected railings.

2. Grout, anchoring cement, and paint products.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified structural engineer responsible for their preparation.

C. Samples for Verification: For each type of exposed finish required.

D. Welding certificates.

E. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of railing through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code - Steel."

1.05 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating railings without field measurements. Coordinate wall and

other contiguous construction to ensure that actual dimensions correspond to established dimensions.

2. Provide allowance for trimming and fitting at site.

1.06 COORDINATION AND SCHEDULING

A. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

B. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Steel Pipe and Tube Railings:

a) Pisor Industries, Inc.

b) Sharpe Products.

c) Wagner, R & B, Inc.; a division of the Wagner Companies.

2.02 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails, unless otherwise indicated.

2.03 STEEL AND IRON

A. Tubing: ASTM A 500 (cold formed) or ASTM A 513, Type 5 (mandrel drawn).

B. Pipe: ASTM A 53/A 53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.

1. Provide galvanized finish for exterior installations and where indicated.

C. Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Castings: Either gray or malleable iron, unless otherwise indicated.

1. Gray Iron: ASTM A 48/A 48M, Class 30, unless another class is indicated or required by structural loads.

2. Malleable Iron: ASTM A 47/A 47M.

2.04 FASTENERS

A. General: Provide the following:

1. Steel Railings: Plated steel fasteners complying with ASTM B 633, Class Fe/Zn 25 for electrodeposited zinc coating.

B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.

C. Fasteners for Interconnecting Railing Components:

1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.

2. Provide Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.

D. Anchors: Provide cast-in-place, chemical or torque-controlled expansion anchors, fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.

2.05 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Shop Primers: Provide primers that comply with Division 9 painting Sections.

C. Zinc-Rich Primer: Complying with SSPC-Paint 20 or SSPC-Paint 29 and compatible with topcoat.

1. Use primer with a VOC content of 420 g/L (3.5 lb/gal.) or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a) Benjamin Moore & Co.; Epoxy Zinc-Rich Primer CM18/19.

b) Carboline Company; Carbozinc 621.

c) ICI Devoe Coatings; Catha-Coat 313.

d) International Coatings Limited; Interzinc 315 Epoxy Zinc-Rich Primer.

e) PPG Architectural Finishes, Inc.; Aquapon Zinc-Rich Primer 97-670.

f) Sherwin-Williams Company (The); Corothane I GalvaPac Zinc Primer.

g) Tnemec Company, Inc.; Tneme-Zinc 90-97.

D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.06 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32” (1 mm), unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections, unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove flux immediately.

4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

I. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.

1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.

J. Form changes in direction as follows:

1. By bending or by inserting prefabricated elbow fittings.

K. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

L. Close exposed ends of railing members with prefabricated end fittings.

M. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is ¼" (6 mm) or less.

N. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work, unless otherwise indicated.

O. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.

P. For railing posts set in concrete, provide steel sleeves not less than 6" (150 mm) long with inside dimensions not less than ½" (13 mm) greater than outside dimensions of post, with steel plate forming bottom closure.

Q. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.07 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

D. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.08 STEEL AND IRON FINISHES

A. For nongalvanized steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves, except galvanize anchors to be embedded in exterior concrete or masonry.

B. Preparation for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.

C. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed railings:

1. Interior Railings Indicated to Receive Zinc-Rich Primer (SSPC Zone 1A): SSPC-SP 6/NACE No. 3, “Commercial Blast Cleaning.”

D. Apply shop primer to prepared surfaces of railings, unless otherwise indicated. Comply with requirements in SSPC-PA 1, “Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel,” for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

E. All railings to be painted in accordance with Section 09900.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements have been clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.02 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.

2. Set posts plumb within a tolerance of 1/16” in 3’ (2 mm in 1 m).

3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed ¼” in 12’ (5 mm in 3 m).

C. Adjust railings before anchoring to ensure matching alignment at abutting joints.

D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.03 RAILING CONNECTIONS

A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.

B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in Part 2 “Fabrication” Article whether welding is performed in the shop or in the field.

C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2” (50 mm) beyond joint on either side, fasten internal sleeve securely to 1 side, and locate joint within 6” (150 mm) of post.

3.04 ANCHORING POSTS

A. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:

3.05 ANCHORING RAILING ENDS

A. Anchor railing ends to concrete and masonry with round flanges connected to railing ends and anchored to wall construction with anchors and bolts.

B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends.

3.06 ATTACHING HANDRAILS TO WALLS

A. Attach handrails to wall with wall brackets. Provide brackets with 1-½" (38-mm) clearance from inside face of handrail and finished wall surface.

1. Use type of bracket with predrilled hole for exposed bolt anchorage.

B. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

C. Secure wall brackets to building construction as follows:

1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.

2. For hollow masonry anchorage, use toggle bolts.

3.07 ADJUSTING AND CLEANING

A. Clean aluminum and stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.

B. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

C. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 9 painting Sections.

3.08 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05521

SECTION 05700- DECORATIVE METAL SIGNAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Custom Perforated Aluminum Signage Wall.

B. Related Requirements:

   1. Section 05500 "Metal Fabrications" for framing, supports and trim.

1.3 COORDINATION

A. Coordinate installation of anchorages for decorative metal signage. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves. Deliver such items to Project site in time for installation.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, including finishing materials.

B. Shop Drawings: Show fabrication and installation details for decorative metal signage.

   1. Include plans, elevations, component details, and attachment details.
   2. Indicate materials and profiles of each decorative metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.

C. Patterns: Made from proposed patterns for each perforation pattern.

D. Samples for Initial Selection: For products involving selection of color, texture, or design.

E. Samples for Verification: For each type of exposed finish.

   1. Sections of linear shapes.

2. Samples of joints showing quality of workmanship.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For fabricator and anodic finisher.

B. Mill Certificates: Signed by manufacturers of aluminum sheets certifying that products furnished comply with requirements.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A firm experienced in producing decorative metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

B. Installer Qualifications: Fabricator of products.

C. Anodic Finisher Qualifications: A firm experienced in successfully applying anodic finishes of type indicated and employing competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

D. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store decorative metal in a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.

1.9 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with decorative metal by field measurements before fabrication and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 DECORATIVE METAL FABRICATORS

A. Accurate Perforating

B. Industrial Metal Supply Company

C. Metals Depot

2.2 METALS, GENERAL

A. Metal Surfaces, General: Use materials with smooth, flat surfaces unless otherwise indicated. Use materials without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

2.3 ALUMINUM

A. Fabricate products from alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties for each aluminum form required not less than that of alloy and temper designated below.

B. Bars and Shapes: ASTM B 221, Alloy 6063-T5/T52.

C. Tubing: ASTM B 210, Alloy 6063-T832.

D. Sheet: ASTM B 209, Alloy 1100.

2.4 FASTENERS

A. Fastener Materials: Unless otherwise indicated, provide the following:

1. Aluminum Items: Type 304 stainless-steel fasteners.
2. Dissimilar Metals: Type 304 stainless-steel fasteners.

B. Fasteners for Anchoring to Other Construction: Unless otherwise indicated, select fasteners of type, grade, and class required to produce connections suitable for anchoring indicated items to other types of construction indicated.

C. Provide concealed fasteners for interconnecting components and for attaching decorative metal items to other work unless otherwise indicated.

1. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

2.5 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

1. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.

B. Universal Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

2.6 FABRICATION, GENERAL

A. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

B. Form decorative metal to required shapes and sizes, true to line and level with true curves and accurate angles and surfaces. Finish exposed surfaces to smooth, sharp, well-defined lines.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.

D. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

E. Mill joints to a tight, hairline fit. Cope or miter corner joints. Fabricate connections that will be exposed to weather in a manner to exclude water.

F. Provide weep holes where water may accumulate. Locate weep holes in inconspicuous locations.

G. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Cut, reinforce, drill, and tap as needed to receive finish hardware, screws, and similar items unless otherwise indicated.

H. Comply with AWS for recommended practices in shop welding. Weld behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded joints of flux, and dress exposed and contact surfaces.

2.7 DECORATIVE METAL SIGNAGE

A. Fabricate decorative metal signage from aluminum sheet of thickness, size, and pattern indicated. Form perforations by punching, cutting, or drilling to produce openings of sizes and shapes indicated. Roll, press, and grind perforated metal to flatten and to remove burrs and deformations.

1. Aluminum sheets to be .190” thick.
2. Alloy: 1100
3. Finish: Clear Anodized
4. Perforated Sections of Panels to be either:

a. Smaller perforations: Round Staggered Perforations, 0.750” diameter holes, on 1.732” centers. 17% open area.
b. Larger perforations: Round Staggered Perforations, 1.5” diameter holes, on 2” centers. 51% open area.

5. Drawings indicate perforated metal patterns required and are based on products of one manufacturer. Perforated metal patterns produced by other manufacturers may be considered, provided deviations are minor and do not change design concept as judged solely by Architect.

B. Mount decorative metal signage panels in sizes and at locations indicated on the drawings.

C. Provide accessory parts and pieces as indicated on the drawings and in this specification in order to mount the panels as indicated on the drawings.

1. Drawings indicate frame profiles required and are based on products of one manufacturer. Similar frame profiles produced by other manufacturers may be considered, provided deviations are minor and do not change design concept as judged solely by Architect.

2.8 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.9 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of decorative metal.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Provide anchorage devices and fasteners where needed to secure decorative metal to in-place construction.

B. Perform cutting, drilling, and fitting required to install decorative metal. Set products accurately in location, alignment, and elevation, measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.

C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of decorative metal, restore finishes to eliminate evidence of such corrective work.

D. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.

E. Install concealed gaskets, joint fillers, insulation, and flashings as work progresses.

F. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.

   1. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.

G. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding and requirements for welding and for finishing welded connections in "Fabrication, General" Article. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

H. Field Brazing: Comply with requirements for brazing and for finishing brazed connections in "Fabrication, General" Article. Braze connections that are not to be left as exposed joints but cannot be shop brazed because of shipping size limitations.

I. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

   1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

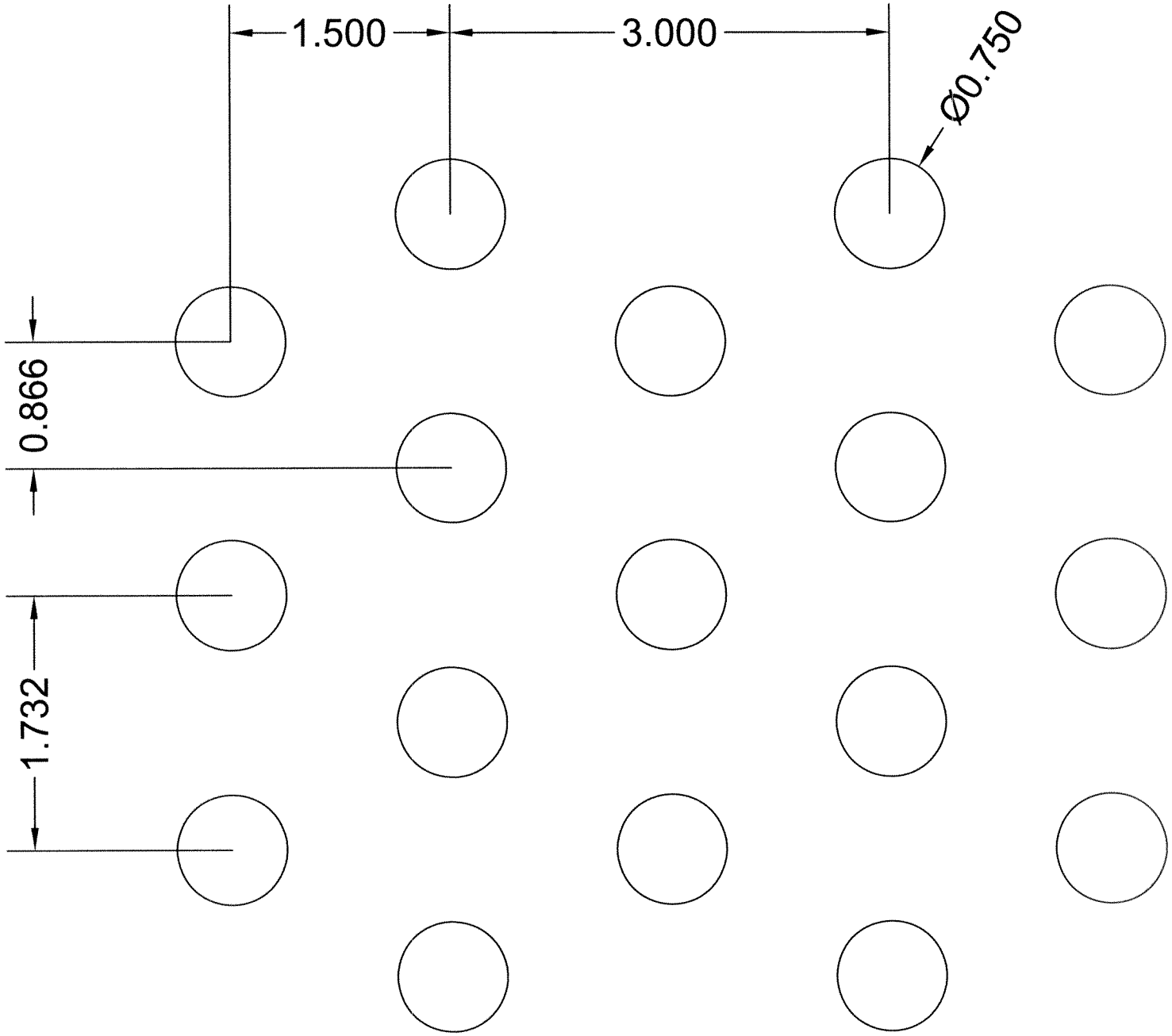
3.3 CLEANING AND PROTECTION

A. Unless otherwise indicated, clean metals by washing thoroughly with clean water and soap, rinsing with clean water, and drying with soft cloths.

B. Protect finishes of decorative metal from damage during construction period with temporary protective coverings approved by decorative metal fabricator. Remove protective covering at time of Substantial Completion.

C. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05700



** HOLE PATTERN IS ACTUAL SIZE **

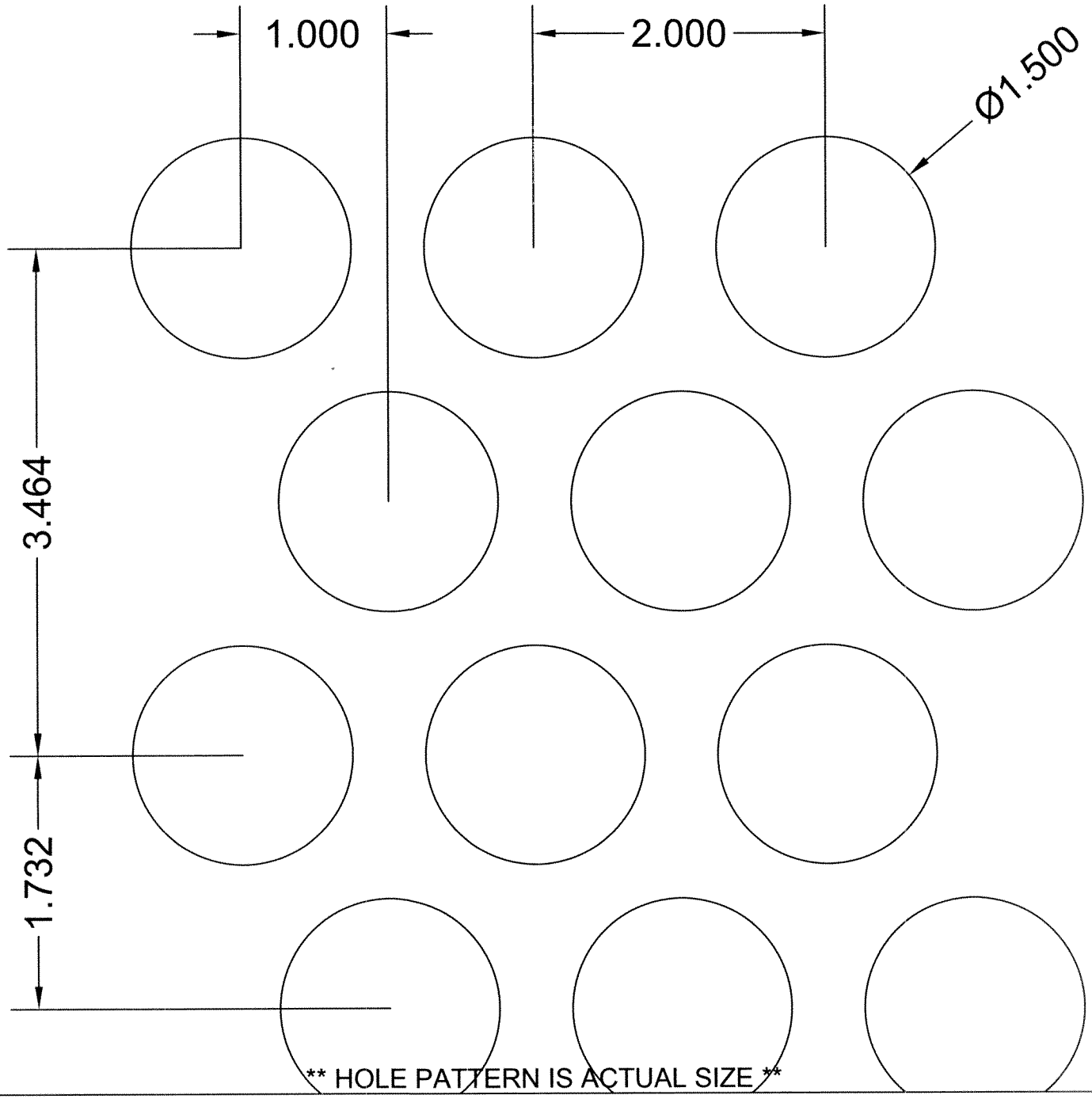
accurate
PERFORATING

3636 S. KEDZIE AVE.
CHICAGO, IL 60632
ph) 800.621.0273
fax) 773.254.9453
www.accurateperforating.com

PATTERN TYPE	Round Staggered
SIZE x CENTERS	0.750" x 1.732"
OPEN AREA	17 %

Tooling Notes :
60S.003FIN3
60H.019FIN3
60H.027FIN3
60H.032FIN3
60H.042FIN3

RS102



** HOLE PATTERN IS ACTUAL SIZE **

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fax) 773.254.9453
www.accurateperforating.com

PATTERN TYPE	SIZE x CENTERS	OPEN AREA
Round Staggered	1.500" x 2.000"	51 %

Tooling Notes :
60H.017FIN
60H.021FIN
60H.042FIN
60H.052FIN

RS112

SECTION 06100 - ROUGH CARPENTRY

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Wood blocking, cants and nailers.

2. Plywood wall panels in elevator machine room and mechanical room

B. Related Sections include the following:

1. Division 9 Section “Gypsum Board Assemblies”

2. Division 9 Section “Painting”

3. Division 10 Section “Toilet, Bath and Laundry Accessories”

1.02 DEFINITIONS

A. Exposed Framing: Framing not concealed by other construction.

B. Dimension Lumber: Lumber of 2” nominal or greater but less than 5” nominal in least dimension.

C. Timber: Lumber of 5” nominal or greater in least dimension.

D. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NeLMA: Northeastern Lumber Manufacturers’ Association.

2. NLGA: National Lumber Grades Authority.

3. RIS: Redwood Inspection Service.

4. SPIB: The Southern Pine Inspection Bureau.

5. WCLIB: West Coast Lumber Inspection Bureau.

6. WWPA: Western Wood Products Association.

1.03 SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials

comply with requirements. Indicate type of preservative used and net amount of preservative retained.

2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.

3. For fire-retardant treatments specified to be High-Temperature (HT) type, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.

4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

B. Fastener Patterns: Full-size templates for fasteners in exposed framing.

C. Material Certificates: For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.

D. Research/Evaluation Reports: For the following, showing compliance with building code in effect for Project:

1. Wood-preservative-treated wood.

2. Fire-retardant-treated wood.

3. Power-driven fasteners.

4. Powder-actuated fasteners.

5. Expansion anchors.

6. Metal framing anchors.

1.04 QUALITY ASSURANCE

A. Source Limitations for Engineered Wood Products: Obtain each type of engineered wood product through one source from a single manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

PART 2. PRODUCTS

2.01 WOOD PRODUCTS, GENERAL

A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each piece of lumber with grade stamp of grading agency.

2. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece

3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

4. Provide dressed lumber, S4S, unless otherwise indicated.

B. Engineered Wood Products: Provide engineered wood products acceptable to authorities having jurisdiction and for which current model code research or evaluation reports exist that show compliance with building code in effect for Project.

1. Allowable Design Stresses: Provide engineered wood products with allowable design stresses, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.

2.02 PLYWOOD BACKING PANELS

A. Backing panels at inside of exterior wall: Fire retardant treated Standard grade plywood with exterior glue, not less than 5/8inch thick, primed and painted in accordance with Section 09900. Do not paint over FRT label.

2.03 FIRE-RETARDANT-TREATED MATERIALS

A. General: Comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood).

1. Use Exterior type for exterior locations and where indicated.

2. Use Interior Type A, High Temperature (HT) for enclosed roof framing, framing in attic spaces, and where indicated.

3. Use Interior Type A, unless otherwise indicated.

B. Identify fire-retardant-treated wood with appropriate classification marking of testing and inspecting agency acceptable to authorities having jurisdiction.

1. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece.

C. For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.

D. Application: Treat all rough carpentry, unless otherwise indicated.

2.04 MISCELLANEOUS LUMBER

A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:

1. Blocking.

2. Nailers.

3. Cants.

4. Furring.

B. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

C. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

2.05 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.

1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.

B. Nails, Brads, and Staples: ASTM F 1667.

C. Power-Driven Fasteners: NES NER-272.

D. Wood Screws: ASME B18.6.1.

E. Lag Bolts: ASME B18.2.1 (ASME B18.2.3.8M).

F. Bolts: Steel bolts complying with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers.

G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.

1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.

2. Material: Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Grade A1 or A4).

PART 3. EXECUTION

3.01 INSTALLATION, GENERAL

A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction," unless otherwise indicated.

C. Framing with Engineered Wood Products: Install engineered wood products to comply with manufacturer's written instructions.

D. Metal Framing Anchors: Install metal framing to comply with manufacturer's written instructions.

E. Install fire-retardant treated plywood backing panels with classification marking of testing agency exposed to view.

F. Do not splice structural members between supports, unless otherwise indicated.

G. Provide blocking and framing as indicated on drawings and as required to support facing materials, fixtures, specialty items, and trim.

1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16” o.c.

H. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

I. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron for items that are continuously protected from liquid water.

2. Use copper naphthenate for items not continuously protected from liquid water.

J. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. NES NER-272 for power-driven fasteners.

2. Table 2304.9.1, “Fastening Schedule,” in ICC’s International Building Code.

3. Table 23-II-B-1, “Nailing Schedule,” and Table 23-II-B-2, “Wood Structural Panel Roof Sheathing Nailing Schedule,” in ICBO’s Uniform Building Code.

4. Table 2305.2, “Fastening Schedule,” in BOCA’s BOCA National Building Code.

5. Table 2306.1, “Fastening Schedule,” in SBCCI’s Standard Building Code.

K. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.

L. For exposed work, arrange fasteners in straight rows parallel with edges of members, with fasteners evenly spaced, and with adjacent rows staggered.

1. Comply with approved fastener patterns where applicable.

2. Use finishing nails, unless otherwise indicated.

3.02 WOOD BLOCKING, AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.

C. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-½" wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

3.03 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 06100

SECTION 06160 - SHEATHING

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Wall sheathing.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

PART 2. PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For assemblies with fire-resistance ratings, provide materials and construction identical to those of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.

1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory."

2.02 WALL SHEATHING

A. Glass-Mat Gypsum Wall Sheathing: ASTM C 1177/1177M.

1. Type and Thickness: Type X, 5/8" thick.

2.03 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. For parapet wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M Or Epoxy coated fasteners.

2.04 SHEATHING JOINT-AND-PENETRATION TREATMENT MATERIALS

A. Sealant for Glass-Mat Gypsum Sheathing: Elastomeric, medium-modulus, neutral-curing silicone joint sealant compatible with joint substrates formed by gypsum sheathing and other materials, recommended by sheathing manufacturer for application indicated and complying with requirements for elastomeric sealants specified in Section 079200 "Joint Sealants."

B. Sealant for Glass-Mat Gypsum Sheathing: Silicone emulsion sealant complying with ASTM C 834, compatible with sheathing tape and sheathing and recommended by tape and sheathing manufacturers for use with glass-fiber sheathing tape and for covering exposed fasteners.

1. Sheathing Tape: Self-adhering glass-fiber tape, minimum 2” wide, 10 by 10 or 10 by 20 threads/inch, of type recommended by sheathing and tape manufacturers for use with silicone emulsion sealant in sealing joints in glass-mat gypsum sheathing and with a history of successful in-service use.

PART 3. EXECUTION

3.01 INSTALLATION, GENERAL

A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.

B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.

C. Securely attach to substrate by fastening as indicated, complying with the following:

1. NES NER-272 for power-driven fasteners.

2. Table 2304.9.1, “Fastening Schedule,” in ICC’s “International Building Code.”

D. Coordinate wall sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

E. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

3.02 GYPSUM SHEATHING INSTALLATION

A. Comply with GA-253 and with manufacturer’s written instructions.

1. Fasten gypsum sheathing to cold-formed metal framing with screws.

2. Install boards with a 3/8” gap where non-load-bearing construction abuts structural elements.

3. Install boards with a ¼” gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.

B. Seal sheathing joints according to sheathing manufacturer’s written instructions.

1. Apply elastomeric sealant to joints and fasteners and trowel flat. Apply sufficient amount of sealant to completely cover joints and fasteners after troweling. Seal other penetrations and openings.

2. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing joints and apply and trowel silicone emulsion sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.

END OF SECTION 06160

SECTION 07115 - BITUMINOUS DAMPPROOFING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit A, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:

1. Cold-applied, emulsified-asphalt dampproofing.

B. Related Sections include the following:

1. Division 07 Section "Self-Adhering Sheet Waterproofing" for waterproofing.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include recommendations for method of application, primer, number of coats, coverage or thickness, and protection course.

B. Material Certificates: For each product, signed by manufacturers.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain primary dampproofing materials and primers through one source from a single manufacturer. Provide secondary materials recommended by manufacturer of primary materials.

1.05 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit dampproofing to be performed according to manufacturers' written instructions.

B. Ventilation: Provide adequate ventilation during application of dampproofing in enclosed spaces. Maintain ventilation until dampproofing has cured.

PART 2 PRODUCTS

2.01 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. ChemMasters Corp.
2. Degussa Building Systems; Sonneborn Brand Products.
3. Gardner Gibson, Inc.
4. Henry Company.
5. Karnak Corporation.
6. Koppers Inc.
7. Malarkey Roofing Products.
8. Meadows, W. R., Inc.
9. Tamms Industries, Inc.

C. Trowel Coats: ASTM D 1227, Type II, Class 1.

D. Fibered Brush and Spray Coats: ASTM D 1227, Type II, Class 1.

E. Brush and Spray Coats: ASTM D 1227, Type III, Class 1.

F. VOC Content: 0.25 lb/gal. (30 g/L) or less.

2.02 PROTECTION COURSE (for use on tunnel top slab)

A. Protection Course, Asphalt-Board Type: ASTM D 6506, premolded, 1/8-inch-(3-mm-) thick, multi-ply, semirigid board consisting of a mineral-stabilized asphalt core sandwiched between layers of asphalt-saturated felt, and faced on 1 side with polyethylene film.

2.03 MISCELLANEOUS MATERIALS

A. Emulsified-Asphalt Primer: ASTM D 1227, Type III, Class 1, except diluted with water as recommended by manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for surface smoothness and other conditions affecting performance of work:

1. Proceed with dampproofing application only after substrate construction and penetrating work have been completed and unsatisfactory conditions have been corrected.
2. Test for surface moisture according to ASTM D 4263.

3.02 PREPARATION

A. Protection of Other Work: Mask or otherwise protect adjoining exposed surfaces from being stained, spotted, or coated with dampproofing. Prevent dampproofing materials from entering and clogging weep holes and drains.

B. Clean substrates of projections and substances detrimental to work; fill voids, seal joints, and apply bond breakers if any, as recommended by prime material manufacturer.

C. Apply patching compound for filling and patching tie holes, honeycombs, reveals, and other imperfections.

3.03 APPLICATION, GENERAL

A. Comply with manufacturer's written recommendations unless more stringent requirements are indicated or required by Project conditions to ensure satisfactory performance of dampproofing.

B. Apply dampproofing to the exterior face of enclosure and building side walls and top slab.

C. Apply protection course to the top slab of enclosure and raised slabs of the building.

3.04 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. On tunnel top and side walls apply no less that a total of 3 gal./100 sq. ft: 1.) Apply two (2) brush or spray coats at not less than 1.5 gal./100 sq. ft (0.6 L/sq. m) for first coat and 1 gal./100 sq. ft (0.4 L/sq. m) for second coat, or 2.) 1 fibered brush or spray coat at not less than 3 gal./100 sq. ft (1.2 L/sq. m).

B. On Unexposed Face of Concrete Retaining Walls: Apply one (1) brush or spray coat at not less than 1.25 gal./100 sq. ft (0.5 L/sq. m).

3.05 INSTALLATION OF PROTECTION COURSE

A. Where indicated, install protection course over completed-and-cured dampproofing. Comply with dampproofing material manufacturer's written recommendations for attaching protection course.

3.06 CLEANING

A. Remove dampproofing materials from surfaces not intended to receive dampproofing.

END OF SECTION 07115

SECTION 07131 – SELF-ADHERING SHEET WATERPROOFING

PART 1. GENERAL

1.01 SUMMARY

A. Section includes self-adhering modified bituminous sheet waterproofing.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.

1.03 INFORMATIONAL SUBMITTALS

A. Product Data

B. Sample warranties.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.

1.05 WARRANTY

A. Manufacturer's Warranty: Manufacturer's standard materials-only warranty in which manufacturer agrees to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.

1. Verify available warranties and warranty periods.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 MODIFIED BITUMINOUS SHEET WATERPROOFING

A. Modified Bituminous Sheet: Minimum 60-mil nominal thickness, self-adhering sheet consisting of 56 mils of rubberized asphalt laminated on one side to a 4-mil- thick, polyethylene-film reinforcement, and with release liner on adhesive side; formulated for application with primer or surface conditioner that complies with VOC limits of authorities having jurisdiction.

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. American Hydrotech, Inc.; VM75.

2. Carlisle Coatings & Waterproofing Inc.; CCW MiraDRI 860/861.

3. CETCO Building Materials Group, a subsidiary of AMCOL International Corp.; Envirosheet.

4. Grace, W. R., & Co. - Conn.; Bituthene 4000.

5. Henry Company; Blueskin WP 100/200.

6. Meadows, W. R., Inc.; SealTight Mel-Rol.

7. Nervastral, Inc.; BITU-MEM.

8. Polyguard Products, Inc.; Polyguard 650.

9. Protecto Wrap Company; PW 100/60.

10. Tamko Building Products, Inc.; TW-60.

11. York Manufacturing, Inc.; HydroGard.

12. Physical Properties:

    a) Tensile Strength, Membrane: 250 psi minimum; ASTM D 412, Die C, modified.

    b) Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.

    c) Low-Temperature Flexibility: Pass at minus 20 deg F ASTM D 1970.

    d) Crack Cycling: Unaffected after 100 cycles of 1/8-inch movement; ASTM C 836.

    e) Puncture Resistance: 40 lbf minimum; ASTM E 154.

    f) Water Absorption: 0.2 percent weight-gain maximum after 48-hour immersion at 70 deg F ASTM D 570.

    g) Water Vapor Permeance: 0.05 perms maximum; ASTM E 96/E 96M, Water Method.

    h) Hydrostatic-Head Resistance: 150 feet minimum; ASTM D 5385.

13. Sheet Strips: Self-adhering, rubberized-asphalt strips of same material and thickness as sheet waterproofing.

2.02 AUXILIARY MATERIALS

A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.

1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.

B. Primer: Liquid waterborne primer recommended for substrate by sheet-waterproofing material manufacturer.

C. Surface Conditioner: Liquid, waterborne surface conditioner recommended for substrate by sheet-waterproofing material manufacturer.

D. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.

E. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.

F. Metal Termination Bars: Aluminum bars, approximately 1 x 1/8” thick, predrilled at 9” centers.

PART 3. EXECUTION

3.01 MODIFIED BITUMINOUS SHEET-WATERPROOFING APPLICATION

A. Prepare surfaces and install modified bituminous sheets according to waterproofing manufacturer’s written instructions and recommendations in ASTM D 6135.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.

C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-½” minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.

D. When ambient and substrate temperatures range between 25° and 40° F install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60° F.

E. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.

F. Seal edges of sheet-waterproofing terminations with mastic. Provide continuous termination bar at grade level, mechanically fastened to concrete foundation walls.

G. Install sheet-waterproofing and auxiliary materials to tie into adjacent waterproofing.

H. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6” beyond repaired areas in all directions.

I. Immediately install protection course with butted joints over waterproofing membrane.

3.02 PROTECTION, REPAIR, AND CLEANING

A. Do not permit foot or vehicular traffic on unprotected membrane.

B. Protect installed insulation drainage panels from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

C. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.

D. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07131

SECTION 07180 – TRAFFIC COATINGS

PART 1. GENERAL

1.01 SUMMARY

A. Section includes Traffic Coatings for the following applications:

1. Floor Covering at both Egress Stairs and Entry.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product, including installation instructions.

B. Shop Drawings: For traffic coatings.

1. Include details for treating substrate joints and cracks, flashings, deck penetrations, and other termination conditions.

C. Samples: For each exposed product and for each color and texture specified.

1.03 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Sample warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace traffic coating that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 MATERIALS, GENERAL

A. Material Compatibility: Provide primers; base-, intermediate-, and topcoat; and accessory materials that are compatible with one another and with substrate under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

2.02 TRAFFIC COATING:

A. Basis of Design: The below listed product serves as the basis of design. Equal products from other manufacturers may be considered for substitution.

B. Traffic Coating: 100 percent solids, two component epoxy floor coating specially designed for use as a protective coating.

1. Manufacturers: Provide products by the following:

a) Benjamin Moore & Co.

2. Product: Super Spec HP, 100% Solids Floor Epoxy P40.

C. Primer: Liquid primer recommended for substrate and conditions by traffic-coating manufacturer.

D. First and Second Coat: Super Spec HP P40, color: Gray.

E. Anti-slip Aggregate: Super Spec HP Anti-slip Aggregate (P67).

2.03 ACCESSORY MATERIALS

A. Joint Sealants: As specified in Section 07901 “Joint Sealants.”

B. Sheet Flashing: Non-staining sheet material recommended in writing by traffic-coating manufacturer.

C. Adhesive: Contact adhesive recommended in writing by traffic-coating manufacturer.

PART 3. EXECUTION

3.01 PREPARATION

A. General: Clean and prepare substrates according to ASTM C 1127 and manufacturer’s written instructions to produce clean, dust-free, dry substrate for traffic-coating application.

1. Application of coating indicates acceptance of surfaces and conditions.

B. Mask adjoining surfaces not receiving traffic coatings to prevent overspray, spillage, leaking, and migration of coatings. Prevent traffic-coating materials from entering deck substrate penetrations and clogging weep holes and drains.

C. Concrete Substrates: Mechanically abrade surface, by either grinding or shot-blasting, to a uniform profile acceptable to manufacturer, according to ASTM D 4259. Do not acid etch.

1. Remove grease, oil, paints, and other penetrating contaminants from concrete.

2. Remove concrete fins, ridges, and other projections.

3. Remove laitance, glaze, efflorescence, curing compounds, concrete hardeners, form-release agents, and other incompatible materials that might affect coating adhesion.

4. Remove remaining loose material to provide a sound surface, and clean surfaces according to ASTM D 4258.

3.02 TERMINATIONS AND PENETRATIONS

A. Prepare vertical and horizontal surfaces at terminations and penetrations through traffic coatings and at expansion joints, drains, and sleeves according to ASTM C 1127 and manufacturer's written instructions.

B. Provide sealant cants at penetrations and at reinforced and non-reinforced, deck-to-wall butt joints.

C. Terminate edges of deck-to-deck expansion joints with preparatory base-coat strip.

D. Install sheet flashings at deck-to-wall expansion and dynamic joints, and bond to deck and wall substrates according to manufacturer’s written recommendations.

3.03 JOINT AND CRACK TREATMENT

A. Prepare, treat, rout, and fill joints and cracks in substrates according to ASTM C 1127 and manufacturer’s written recommendations. Before coating surfaces, remove dust and dirt from joints and cracks according to ASTM D 4258.

1. Comply with recommendations in ASTM C 1193 for joint-sealant installation.

B. Apply reinforcing strip in traffic-coating system where recommended in writing by traffic-coating manufacturer.

3.04 TRAFFIC-COATING APPLICATION

A. Apply traffic coating according to ASTM C 1127 and manufacturer’s written instructions.

B. Apply number of coats of specified compositions for each type of traffic coating at locations as indicated on Drawings. Minimum total dry film thickness of 16 mils, applied in two coats.

C. Apply traffic coatings to prepared wall terminations and vertical surfaces to height indicated; omit aggregate on vertical surfaces.

D. Anti-slip aggregate: Within 30 minutes after applying the first coat, hand broadcast the Anti-slip aggregate into the first coat, taking care to leave 12" unsanded area on each edge for the next batch to overlap. Wearing spiked shoes, lightly back roll the aggregate into the coating so it is encapsulated.

E. Cure traffic coatings.

3.05 PROTECTING AND CLEANING

A. Protect traffic coatings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 07180

SECTION 07210 - BUILDING INSULATION

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Foam-plastic board insulation – Rigid board foundation insulation.

1.02 ACTION SUBMITTALS

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

1.03 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2. PRODUCTS

2.01 FOAM-PLASTIC BOARD INSULATION

A. Extruded-Polystyrene Board Insulation: ASTM C 578, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a) DiversiFoam Products.

b) Dow Chemical Company (The).

c) Owens Corning.

d) Pactiv Building Products.

2. Type IV, 25 psi.

3. Thickness: 2”

4. R-Value: R-10

PART 3. EXECUTION

3.01 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and applications indicated.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Extend insulation to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.02 INSTALLATION OF BELOW-GRADE INSULATION

A. On vertical surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.

1. If not otherwise indicated, extend insulation a minimum of 36" below exterior grade line.

2. Areas without below-grade spaces: place insulation 36" along the inside face of the exterior foundation wall.

3. Where shown on drawings, place insulation full height from bottom of foundation wall to grade on outside of foundation wall.

B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

1. If not otherwise indicated, extend insulation a minimum of 36" in from exterior walls.

2. Areas without below-grade spaces: place insulation within 36" of foundation wall under concrete slab on grade.

END OF SECTION 07210

SECTION 07413 – INSULATED-CORE METAL WALL PANELS

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes foamed-insulation-core horizontal and vertical metal wall panel assembly with integral reveals and profiled panels, with related metal trim and accessories including integrated components. Specifically:

1. Horizontal and Vertical Flat insulated-core metal wall panels.

2. Metal Wall Panel Manufacturer's Standard Integral Insulated Glazing System

1.02 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.

C. Samples: For each type of metal panel indicated.

1.04 INFORMATIONAL SUBMITTALS

A. Product test reports.

B. Warranties: Samples of special warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Finish Warranty Period: 20 years from date of Substantial Completion.

1.07 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 72:

1. Wind Loads: As indicated on Structural Drawings.

B. Deflection Limits: For wind loads, no greater than 1/180Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 283 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft.

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:

1. Test-Pressure Difference: 15.00 lbsf/sq. ft.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120° F , ambient; 180° F.

E. Fire-Test-Response Characteristics: Provide metal wall panels and system components with the following fire-test-response characteristics, as determined by testing identical panels and system components per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.

1. Fire-Resistance Characteristics: Provide materials and construction tested for fire resistance per ASTM E 119.

2. Intermediate-Scale Multistory Fire Test: Tested mockup, representative of completed multistory wall assembly of which wall panel is a part, complies with NFPA 285 for test method and required fire-test-response characteristics of exterior non-load-bearing wall panel assemblies.

3. Radiant Heat Exposure: No ignition when tested according to NFPA 268.

4. Potential Heat: Acceptable level when tested according to NFPA 259.

5. Surface-Burning Characteristics: Provide wall panels with a flame-spread index of 25 or less and a smoke-developed index of 450 or less, per ASTM E 84.

PART 2. PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Insulated Core Metal Wall Panel System: Factory-foamed-in-place horizontal and vertical wall panel system consisting of exterior metal face sheet with interior metal liner panel, bonded to factory foamed-in-place core in thermally-separated profile, utilizing no glues or adhesives, with factory sealed tongue-and-groove and pressure-equalized rain screen-designed horizontal joint, attached to supports using concealed fasteners.

1. System is to be provided complete with integral louvers.

B. Manufacturer's Standard 1" Insulated Insulated Window System.

2.02 MANUFACTURERS

A. Basis of Design: CENTRIA, Formawall Dimension Series Insulated Core Metal Wall Panels or Fermilab approved equal.

2.03 PANEL MATERIALS

A. Metallic-Coated Steel Face Sheet: Coil-coated, ASTM A 755

1. Zinc-Coated (Galvanized) Steel Sheet: ASTMA 653, G90, structural quality

2. Face Sheet Thickness: As required to meet performance requirements, minimum 0.030 inch/22 gauge thick

3. Surface: Smooth unless indicated as embossed on the drawings.

4. Finish: Standard fluoropolymer two-coat system consisting of 0.2 mil primer with 0.8 mil 70 percent PVDF fluoropolymer color coat.

5. Color to be selected by Owner from manufacturer's full range of standard colors.

B. Foamed Insulation Core: Foamed-in-place Urethane or isocyanurate containing no CFC or HCFC compounds.

1. Density: 2.7 lb/cu. ft min compressive strength 20 lb/sq. in.

C. Metallic-Coated Steel Liner Sheet: Coil-coated, ASTM A 755.

1. Zinc-Coated (Galvanized) Steel Sheet: ASTMA 653, G90, structural quality.

2. Liner Sheet Thickness: 0.030 inch/22 gauge thick.

3. Surface: Smooth.

4. Interior Liner Panel Finish: 0.2 mil primer with 0.6 mil acrylic finish.

D. Exposed Trim and Fasteners: Match panel finish

2.04 HORIZONTAL & VERTICAL FLAT INSULATION-CORE METAL WALL PANELS – ***TYPE B-1***

A. Basis of Design: CENTRIA, Formawall Dimension Series 3”-T Vertical Flat Insulated Core Metal Wall Panels.

1. Panel Thickness: 3”

2. Panel Width: 36”

3. Profile: Flat.

4. Thermal Resistance: R-22

5. Joint: Double tongue-and-groove – 1/8” nominal with Factory applied non-curing butyl.

6. Panel Ends: Factory formed trim-less ends, tabbed under panel horizontal shelf

B. Glass Type GL-2: Low-e-coated, tinted insulating glass (Grey)

1. Overall Unit Thickness: 1”.

2. Thickness of Each Glass Lite 6.0 mm (1/4”).

3. Outdoor Lite: fully tempered coated and tinted float glass.

4. Interspace Content: Air.

5. Indoor Lite: fully tempered clear float glass.

6. Basis of Design: Pilkington Eclipse Advantage (Solar Control Low-E) – Grey

7. Color: Grey

8. Low-E Coating: Pyrolytic or sputtered on second surface.

9. Visible Light Transmittance: 29 percent minimum.

10. Winter Nighttime U-Factor: 0.35 maximum.

11. Summer Daytime U-Factor: 0.35 maximum.

12. Solar Heat Gain Coefficient: 0.33 maximum.

2.05 MISCELLANEOUS MATERIALS

A. Panel Accessories: Provide complete metal wall panel assembly incorporating trim, copings, fasciae, parapet caps, soffits, sills, inside and outside corners, and miscellaneous flashings. Provide manufacturer's factory-formed clips, shims, flashings, gaskets, lap tapes, closure strips, and caps for a complete installation. Fabricate and install accessories in accordance with SMACNA Manual.

1. Closures: Provide closures at eaves and rakes, fabricated of same metal as metal panels.

2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

3. Closure Strips: Closed-cell, expanded, cellular, rubber or cross-linked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1" thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weather tight construction.

B. Flashing and Trim: Provide flashing and trim formed from same gage material as metal panels. Locations include, but are not limited to, bases, drips, sills, jambs, corners, end walls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal panels. Provide aluminum extrusions where shown on drawings.

C. Extrusion Trim: Provide manufacturer-provided extruded trim for the following locations and as indicated on Drawing:

1. Base trim.

2. Panel installation perimeter.

3. Opening perimeters

D. Vertical Joint Seal Plate: Extruded aluminum seal plate with combination neoprene gasket and non-curing butyl dual seal forming pressure-equalized vented chamber permitting moisture to drain to exterior. Seal plate capable of transferring panel loads to vertical supports. Resultant vertical panel joint shall meet performance requirements.

1. Performance: Vertical joint design shall effectively demonstrate pressure equalization and be evaluated in accordance with ASTM E 283-04 and ASTM E 331-00. A third party test indicating the successful passing of these tests and noting effective pressure equalization must be submitted prior to bid

E. Panel Clips: Concealed stainless steel clip configured specifically for metal wall panel profile, engaging face and liner panel edge without compressing panel insulation

F. Panel Fasteners: Self-tapping screws, bolts, nuts, and other acceptable fasteners recommended by panel manufacturer. Where exposed fasteners cannot be avoided, supply corrosion-resistant fasteners with heads matching color of metal wall panels

G. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyiso-butylene compound sealant tape with release-paper backing.

2. Joint Sealant: ASTM C 920; as recommended in writing by metal panel manufacturer.

3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.06 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer’s standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weather tight seal and prevent metal-to-metal contact, and that minimize noise from movements.

D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA’s “Architectural Sheet Metal Manual” that apply to design, dimensions, metal, and other characteristics of item indicated.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine metal wall panel supports, substrates, and conditions for compliance with requirements for installation tolerances and other conditions affecting work.

1. Verify that structural panel support members and anchorage have been installed within the following tolerances:

a. Plus or minus ¼” in 20’.

b. Plus or minus ½” across building elevation.

c. Plus or minus 1/8” within 5’ of any change in plane.

B. Correct out of tolerance work and deficient conditions prior to proceeding with metal wall panel installation.

3.02 PREPARATION

A. Miscellaneous Supports: Install sub-framing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.03 INSULATED-CORE METAL WALL PANEL INSTALLATION

A. General: Install metal wall panels in orientation, sizes, and locations indicated. Anchor metal wall panels and other components securely in place. Provide for thermal and structural movement.

1. Apply continuous ribbon of sealant to panel joint on concealed side of insulated metal wall panels as vapor seal; apply sealant to panel joint on exposed side of panels for weather seal.

2. Fasten metal wall panels to supports with concealed fasteners at each lapped joint at location and spacing and with fasteners recommended by manufacturer.

3. Apply panels and associated items true to line for neat and weather tight enclosure. Avoid “panel creep” or application not true to line.

4. Provide sealant tape at lapped joints of insulated metal wall panels and between panels and protruding equipment, vents, and accessories.

5. Apply a continuous ribbon of sealant tape to panel side laps and elsewhere as needed to make panels weather tight.

6. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

B. Foamed-Insulation-Core Metal Wall Panels: Fasten metal wall panels to supports with concealed clips at each joint at location and spacing and with fasteners recommended by manufacturer. Fully engage tongue and groove of adjacent panels.

1. Install clips to supports with self-tapping fasteners.

C. Accessory Installation: Install accessories with positive anchorage to building and weather tight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

D. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that are permanently watertight.

3.04 ACCESSORY INSTALLATION

A. General: Install metal wall panel accessories with positive anchorage to building and weather tight mounting and provide for thermal expansion. Coordinate installation with flashings and other components:

1. Install related flashings and sheet metal trim per requirements of Division 07 Section "Flashing and Sheet Metal."

2. Install components required for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

3. Comply with performance requirements and manufacturer's written installation instructions.

4. Provide concealed fasteners except where noted on approved shop drawings.

5. Set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant

3.05 CLEANING

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. Replace damaged panels and accessories that cannot be repaired by finish touch-up or minor repair.

END OF SECTION 07413

SECTION 07510 - BUILT-UP BITUMINOUS ROOFING

PART 1. GENERAL

1.01 SUMMARY

A. Section includes built-up asphalt roofing.

1.02 DEFINITION

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

1.03 PERFORMANCE REQUIREMENTS

A. Roofing System Design: Provide built-up roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.

1. Corner Uplift Pressure: 65 lbf/sq. ft.

2. Perimeter Uplift Pressure: 45 lbf/sq. ft.

3. Field-of-Roof Uplift Pressure: 25 lbf/sq. ft.

B. Energy Performance: Provide roofing system that is listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low-slope roof products.

C. Energy Performance: Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.75 when tested according to CRRC-1.

1.04 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Verification: For cap sheet and flashing sheet, of color specified.

1.05 INFORMATIONAL SUBMITTALS

A. Research/evaluation reports.

B. Sample warranties.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by built-up roofing manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

B. Source Limitations: Obtain components for built-up roofing from same manufacturer as built-up roofing or approved by built-up roofing manufacturer.

C. Pre-installation Roofing Conference: Conduct conference at Project site.

1.08 WARRANTY

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

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 BUILT-UP ROOFING MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Barrett Company.

2. CertainTeed Corp.

3. Ecology Commercial and Industrial Roofing Systems.

4. Fields Company, LLC.

5. Firestone Building Products.

6. GAF Materials Corporation.

7. Hickman, W. P. Systems, Inc.

8. Johns Manville.

9. Malarkey Roofing Company.

10. TAMKO Building Products, Inc.

11. Tremco, Incorporated.

12. U.S. Intec, Inc.; Division of BMCA.

2.02 BASE-SHEET MATERIALS

A. Base Sheet: ASTM D 4601, Type II, SBS-modified, asphalt-impregnated and -coated sheet, with glass-fiber-reinforcing mat, dusted with fine mineral surfacing on both sides.

1. Weight: 25 lb/100 sq. ft. minimum.

2. Basis of Design: Johns Manville GlasBase Plus.

2.03 ROOFING MEMBRANE PLIES

A. Ply Sheet: ASTM D 2178, Type VI, asphalt-impregnated, glass-fiber felt.

1. Basis of Design: Johns Manville GlasPly Premier.

B. Cap Sheet: ASTM D 3909, asphalt-impregnated and -coated, glass-fiber cap sheet, with white coarse mineral-granule top surfacing and fine mineral surfacing on bottom surface.

1. Basis of Design: Johns Manville GlasKap CR.

2.04 BASE FLASHING SHEET MATERIALS

A. Granule-Surfaced Flashing Sheet: ASTM D 6221, Grade G, Type I or II, composite polyester-reinforced and glass-fiber-reinforced, APP-modified asphalt sheet; granular surfaced; suitable for application method specified, and as follows:

1. Granule Color: White

2. Basis of Design: Johns Manville DynaFlex CR

2.05 ASPHALT MATERIALS

A. Asphalt Primer: ASTM D 41.

B. Roofing Asphalt: ASTM D 312, Type II or III as recommended by built-up roofing manufacturer for application.

2.06 AUXILIARY BUILT-UP ROOFING MATERIALS

A. General: Auxiliary materials recommended by roofing manufacturer for intended use and compatible with built-up roofing.

1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.

2. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

a) Plastic Foam Adhesives: 50 g/L.

b) Gypsum Board and Panel Adhesives: 50 g/L.

c) Multipurpose Construction Adhesives: 70 g/L.

d) Fiberglass Adhesives: 80 g/L.

e) Contact Adhesives: 80 g/L.

f) Other Adhesives: 250 g/L.

g) Nonmembrane Roof Sealants: 300 g/L.

h) Sealant Primers for Nonporous Substrates: 250 g/L.

i) Sealant Primers for Porous Substrates: 775 g/L.

B. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required by roofing manufacturer for application.

C. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening built-up roofing components to substrate, tested by manufacturer for required pullout strength, and acceptable to roofing manufacturer.

2.07 ROOF INSULATION

A. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2, felt or glass-fiber mat facer on both major surfaces. The total thickness shall have a minimum thermal resistance (R-value) of 30.

1. Basis of Design: Johns Manville ValueTherm 25PSI

B. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.08 INSULATION ACCESSORIES

A. Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation to substrate and acceptable to roofing manufacturer.

B. Cold-Applied Insulation Adhesive: Insulation manufacturer's recommended asbestos-free, cold-applied adhesive formulated to attach roof insulation to substrate or to another insulation layer.

C. Insulation Cant Strips: ASTM C 208, Type II, Grade 1, cellulosic-fiber insulation board.

D. Cover Board: ASTM C 208, Type II, Grade 2, cellulosic-fiber insulation board, ½” thick.

2.09 WALKWAYS

A. Walkway Pads: Polymer-modified, reconstituted solid-rubber, surface-textured, slip-resisting pads, manufactured as a traffic pad for foot traffic and acceptable to roofing manufacturer, 3/8 inch thick, minimum.

1. Pad Size: 24” x 24”.

PART 3. EXECUTION

3.01 INSULATION INSTALLATION

A. Comply with built-up roofing manufacturer’s written instructions for installing roof insulation.

B. Insulation Cant Strips: Install and secure preformed 45° insulation cant strips at junctures of built-up roofing with vertical surfaces or angle changes greater than 45°.

C. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2” or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6”) in each direction.

1. Where installing composite and noncomposite board insulation in two or more layers, install noncomposite board insulation for bottom layer and intermediate layers, if applicable, and install composite board insulation for top layer.

D. Install tapered edge strips at perimeter edges of roof that do not terminate at vertical surfaces.

E. Mechanically Fastened and Adhered Insulation: Install first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.

1. Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.

2. Set each subsequent layer of insulation in cold-applied insulation adhesive, firmly pressing and maintaining insulation in place.

F. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches in each direction. Loosely butt cover boards together and fasten to roof deck.

1. Fasten cover boards to resist uplift pressure at corners, perimeter, and field of roof.

2. Apply hot roofing asphalt to underside and immediately bond cover board to substrate.

3.02 BUILT-UP ROOFING INSTALLATION

G. Coordinate installation of roofing so insulation and other components of built-up roofing not permanently exposed are not subjected to precipitation or left uncovered at the end of the workday or when rain is forecast.

H. Substrate-Joint Penetrations: Prevent roofing asphalt and adhesives from penetrating substrate joints, entering building, or damaging built-up roofing components or adjacent building construction.

I. Install lapped base sheet course, extending sheet over and terminating beyond cants. Attach base sheet as follows:

1. Adhere to substrate in a solid mopping of hot roofing asphalt.

J. Install two ply sheets starting at low point of roofing. Align ply sheets without stretching. Shingle side laps of ply sheets uniformly to achieve required number of plies throughout thickness of roofing membrane. Shingle in direction to shed water. Extend ply sheets over and terminate beyond cants.

1. Embed each ply sheet in a solid mopping of hot roofing asphalt applied at rate required by roofing manufacturer, to form a uniform membrane without ply sheets touching.

K. Cap Sheet: Install lapped granulated cap sheet starting at low point of roofing. Offset laps from laps of preceding ply sheets and align cap sheet without stretching. Lap in direction to shed water. Extend cap sheet over and terminate beyond cants.

1. Embed cap sheet in a solid mopping of hot roofing asphalt applied at rate required by built-up roofing manufacturer.

3.03 FLASHING AND STRIPPING INSTALLATION

A. Install base flashing over cant strips and other sloping and vertical surfaces, at roof edges, and at penetrations through roof, and secure to substrates according to built-up roofing manufacturer’s written instructions.

B. Extend base flashing up walls or parapets a minimum of 8” above built-up roofing and 4” onto field of built-up roofing.

C. Mechanically fasten top of base flashing securely at terminations and perimeter of roofing.

D. Install stripping, according to roofing manufacturer’s written instructions, where metal flanges and edgings are set on built-up roofing.

E. Roof Drains: Set 30” x 30” metal flashing in bed of asphalt roofing cement on completed built-up roofing. Cover metal flashing with built-up roofing cap-sheet stripping and extend a minimum of 4” beyond edge of metal flashing onto field of built-up roofing. Clamp built-up roofing, metal flashing, and stripping into roof-drain clamping ring.

3.04 WALKWAY INSTALLATION

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

1. Set walkway pads in additional pour coat of hot roofing asphalt after sweeping away loose aggregate surfacing.

END OF SECTION 07510

SECTION 07600 - FLASHING AND SHEET METAL

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Manufactured reglets with counter-flashing.
2. Formed roof-drainage sheet metal fabrications.
3. Formed wall sheet metal fabrications.

1.02 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For sheet metal flashing and trim.

1. Include plans, elevations, sections, and attachment details.
2. Distinguish between shop- and field-assembled work.
3. Include identification of finish for each item.
4. Include pattern of seams and details of termination points, expansion joints and expansion-joint covers, direction of expansion, roof-penetration flashing, and connections to adjoining work.

C. Samples: For each exposed product and for each color and texture specified.

1.04 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

C. Sample warranty.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Fabricator Qualifications: Employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.

1.07 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.

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

PART 2. PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.

B. Sheet Metal Standard for Flashing and Trim: Comply with SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

C. Sheet Metal Standard for Copper: Comply with CDA's "Copper in Architecture Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.

D. SPRI Wind Design Standard: Manufacture and install copings tested according to SPRI ES-1 and capable of resisting the following design pressure:

1. Design Pressure: As required by applicable code.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120° F ambient.

2.02 SHEET METALS

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

B. Stainless steel as indicated on the drawings shall conform to ASTM A-240/A-240M or ASTM A-666, Type 304, soft temper, number 4 finish. Stainless steel sheet metal shall be of the gauges as indicated on the drawings.

C. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, with temper as required to suit forming operations and performance required.

1. Exposed Coil-Coated Finish (to match adjacent wall panel material and finish):

   a) Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2. Color: As selected by owner from manufacturer's standard color chart.

D. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet according to ASTM A 653/A 653M, G90 coating designation or aluminum-zinc alloy-coated steel sheet according to ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 pre-painted by coil-coating process to comply with ASTM A 755/A 755M.

1. Exposed Coil-Coated Finish:

   a) Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2. Color: As selected by owner from manufacturer's standard color chart.

2.03 UNDERLAYMENT MATERIALS

A. Felt: ASTM D 226/D 226M, Type II (No. 30), asphalt-saturated organic felt; non-perforated.

B. Self-Adhering, High-Temperature Sheet: Minimum 30 mils thick, consisting of a slip-resistant polyethylene- or polypropylene-film top surface laminated to a layer of butyl- or SBS-modified asphalt adhesive, with release-paper backing; specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer according to written recommendations of underlayment manufacturer.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a) Grace Construction Products, a unit of W. R. Grace & Co.-Conn.; Grace Ice and Water Shield HT.

2. Thermal Stability: ASTM D 1970; stable after testing at 240° F or higher.

3. Low-Temperature Flexibility: ASTM D 1970; passes after testing at minus 20° F or lower.

C. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft. minimum.

2.04 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.

1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.

a) Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.

b) Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.

c) Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

2. Fasteners for Zinc-Coated (Galvanized) Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

3. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.

C. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, non-sag, nontoxic, non-staining tape ½” wide and 1/8” thick.

D. Elastomeric Sealant: ASTM C 920, elastomeric polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

E. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

F. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

G. Bituminous Coating: Cold-applied asphalt emulsion according to ASTM D 1187.

H. Asphalt Roofing Cement: ASTM D 4586, asbestos free, of consistency required for application.

2.05 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with details shown and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required. Fabricate sheet metal flashing and trim in shop to greatest extent possible.

1. Obtain field measurements for accurate fit before shop fabrication.

2. Form sheet metal flashing and trim to fit substrates without excessive oil canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.

3. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.

B. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.

1. Form expansion joints of intermeshing hooked flanges, not less than 1” deep, filled with butyl sealant concealed within joints.

2. Use lapped expansion joints only where required.

C. Sealant Joints: Where movable, non-expansion-type joints are required, form metal to provide for proper installation of elastomeric sealant according to cited sheet metal standard.

D. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

E. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard for application, but not less than thickness of metal being secured.

F. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.

2.06 ROOF-DRAINAGE SHEET METAL FABRICATIONS

A. Downspouts: Fabricate stainless steel rectangular open-face downspouts to dimensions indicated, complete with mitered elbows. Furnish with metal

hangers from same material as downspouts and anchors. Fabricate from the following material:

1. Material: 18 gauge Pre-finished Galvanized Steel
2. Profile: As shown on drawings
3. Finish: Kynar 500 Fluoropolymer
4. Color: As selected by Fermilab Construction Coordinator. Color to match wall panels
5. Straps: Provide downspout straps at three locations each downspout.

B. Parapet Scuppers: Fabricate scuppers to dimensions required, with closure flange trim to exterior, 4” wide wall flanges to interior, and base extending 4” beyond cant or tapered strip into field of roof. Fabricate from the following material:

1. Material: 18 gauge Pre-finished Galvanized Steel
2. Profile: As shown on drawings
3. Finish: Kynar 500
4. Color: As selected by Fermilab Construction Coordinator. Color to match wall panels

C. Conductor Heads: Fabricate conductor heads with flanged back and stiffened top edge and of dimensions and shape required, complete with outlet tubes. Fabricate from the following material:

1. Material: 18 gauge Pre-finished Galvanized Steel
2. Profile: As shown on drawings
3. Finish: Kynar 500
4. Color: As selected by Fermilab Construction Coordinator. Color to match downspout and scuppers

D. Splash Block: Precast concrete splash block.

2.07 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Copings: Fabricate in minimum 96” long, but not exceeding 12’ long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and interior leg. Miter corners, fasten and seal watertight.

1. Material: 18 gauge Pre-finished Galvanized Steel

2. Profile: As shown on drawings

3. Finish: Kynar 500

4. Color: As selected by Fermilab Construction Coordinator. Color to match metal wall panels

B. Base Flashing: Fabricate from the following materials:

1. Prefinished Galvanized Steel: 0.028” thick.

C. Counter-flashing and Flashing Receivers: Fabricate from the following materials:

1. Prefinished Galvanized Steel: 0.022” thick.

2.08 WALL SHEET METAL FABRICATIONS

A. Through Wall Flashing: Fabricate continuous flashings in minimum 96” long, but not exceeding 12’ long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6” beyond each side of wall openings; and form with 2” high, end dams. Fabricate from the following materials:

1. Material: 18 gauge Pre-finished Galvanized Steel

B. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings. Form head and sill flashing with 2” high, end dams. Fabricate from the following materials:

1. Material: 18 gauge Pre-finished Galvanized Steel

C. Wall Expansion-Joint Cover: Fabricate from the following materials:

1. Material: 18 gauge Pre-finished Galvanized Steel

PART 3. EXECUTION

3.01 UNDERLAYMENT INSTALLATION

A. Felt Underlayment: Install felt underlayment, wrinkle free, using adhesive to minimize use of mechanical fasteners under sheet metal flashing and trim. Apply in shingle fashion to shed water, with lapped joints of not less than 2”.

B. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Prime substrate if recommended by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches staggered 24” between courses. Overlap side edges not less than 3-½” inches. Roll laps and edges with roller. Cover underlayment within 14 days.

3.02 INSTALLATION, GENERAL

A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.

2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

3. Space cleats not more than 12” apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.

4. Install exposed sheet metal flashing and trim with limited oil canning, and free of buckling and tool marks.

5. Torch cutting of sheet metal flashing and trim is not permitted

B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.

1. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10’ with no joints within 24” of corner or intersection.

1. Form expansion joints of intermeshing hooked flanges, not less than 1” deep, filled with sealant concealed within joints.

D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

F. Seal joints as required for watertight construction. Prepare joints and apply sealants to comply with requirements in Section 079200 “Joint Sealants.”

3.03 ROOF-DRAINAGE SYSTEM INSTALLATION

A. General: Install sheet metal roof-drainage items to produce complete roof-drainage system according to cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.

B. Downspouts: Join sections with 1-½” telescoping joints. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60” o.c.

C. Splash Block: Install where downspouts discharge on low-slope roofs. Set in asphalt roofing cement or elastomeric sealant compatible with the substrate.

D. Parapet Scuppers: Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.

E. Conductor Heads: Anchor securely to wall, with elevation of conductor head rim at minimum of 1” below scupper discharge.

3.04 ROOF FLASHING INSTALLATION

A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer’s written installation instructions, and cited sheet metal standard. Provide concealed fasteners where possible, and set units true to line, levels, and slopes. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Copings: Anchor to resist uplift and outward forces according to recommendations in cited sheet metal standard unless otherwise indicated.

C. Pipe or Post Counter-flashing: Install counter-flashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4” over base flashing. Install stainless-steel draw band and tighten.

D. Counter-flashing: Coordinate installation of counter-flashing with installation of base flashing. Insert counter-flashing in reglets or receivers and fit tightly to base flashing. Extend counter-flashing 4” over base flashing. Lap counter-flashing joints minimum of 4”.

3.05 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder.

C. Clean off excess sealants.

D. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in Manufacturer's written installation instructions.

END OF SECTION 07600

SECTION 07720 - ROOF ACCESSORIES

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Roof curbs.
2. Equipment supports.
3. Automatic Roof Smoke Vents.
4. Safety Railing System.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of roof accessory indicated.

B. Shop Drawings: For roof accessories.

C. Samples: For each exposed product and for each color and texture specified.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items.

B. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 WARRANTY

A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within 10 years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 METAL MATERIALS

A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation.

1. Exposed Coil-Coated Finish: Two-coat fluoropolymer finish; AAMA 621; system consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

B. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, AZ50 coated.

1. Exposed Coil-Coated Finish: Two-coat fluoropolymer finish; AAMA 621; system consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight

C. Aluminum Extrusions and Tubes: ASTM B 221, manufacturer's standard alloy and temper for type of use, finished to match assembly where used, otherwise mill finished.

D. Stainless-Steel Sheet and Shapes: ASTM A 240/A 240M or ASTM A 666, Type 304.

2.02 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

B. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, acceptable to authorities having jurisdiction, containing no arsenic or chromium, and complying with AWPA C2; not less than 1-½" thick.

C. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide non-removable fastener heads to exterior exposed fasteners.

D. Sealants: As recommended by roof accessory manufacturer for installation indicated.

2.03 ROOF CURBS

A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings; with welded or mechanically fastened and sealed corner joints, and integrally formed deck-mounting flange at perimeter bottom.

1. Manufacturer: Subject to compliance with requirements, provide a product from one of the following:

   a) AES Industries, Inc.

   b) Curbs Plus, Inc.

   c) Custom Solution Roof and Metal Products.

   d) Greenheck Fan Corporation.

   e) LM Curbs.

   f) Metallic Products Corp.

   g) Milcor Inc.; Commercial Products Group of Hart & Cooley, Inc.

   h) Pate Company (The).

   i) Roof Products, Inc.

   j) Safe Air of Illinois.

   k) Thybar Corporation.

   l) Vent Products Co., Inc.

B. Material: Zinc-coated (galvanized) 0.052” thick.

   1. Finish: Mill phosphatized

C. Construction:

   1. Insulation: Factory insulated with 1-½” cellulosic or glass-fiber board insulation.

   2. Liner: Same material as curb, of manufacturer’s standard thickness and finish.

   3. Factory-installed wood nailer at top of curb, continuous around curb perimeter.

   4. Fabricate curbs to minimum height of 12” unless otherwise indicated.

   5. Where roof slopes, fabricate curb with perimeter curb height tapered to accommodate roof slope so that top surface of perimeter curb is level. Equip unit with water diverter or cricket on side that obstructs water flow.

2.04 AUTOMATIC ROOF SMOKE VENTS

A. Hatch-Type Automatic Roof Smoke Vents: Manufacturer's standard, with double-walled insulated curbs, welded or mechanically fastened and sealed corner joints, integral condensation gutter, and cap flashing. Fabricate with insulated double-walled lid and continuous weathertight perimeter lid gaskets, and equip with automatic self-lifting mechanisms and UL-listed fusible links rated at 165° F smoke-detection system.

1. Basis-of-Design Product: Subject to compliance with requirements, provide pre-assembled Babcock-Davis BSVLB 48" x 48" D2NR LightMAX Double Door Automatic Roof Smoke Vent or comparable product by one of the following:

   a) Bilco Company (The).

   b) Bristolite Skylights.

   c) Dur-Red Products.

   d) J. L. Industries, Inc.

   e) Naturalite Skylight Systems; Vistawall Group (The).

   f) Nystrom.

2. Type and Size: Double-leaf lid, 48" x 48".

3. Loads: Minimum 40-lbf/sq. ft. external live load and 30-lbf/sq. ft. internal uplift load.

   a) When release is actuated, lid shall open against 10-lbf/sq. ft. snow or wind load and lock in position.

   b) Hatch-Lid Glazing: Minimum 40-lbf/sq. ft. external live load and 20-lbf/sq. ft. internal uplift load.

4. Heat and Smoke Vent Standard: Provide units that have been tested and listed to comply with UL 793.

5. Curb, Framing, and Lid Material: Zinc-coated (galvanized) steel sheet, 0.079" thick.

   a) Finish: Two-coat fluoropolymer.

   b) Color: As selected by Architect from manufacturer's full range

6. Construction:

   a) Insulation: Polyisocyanurate board.

   b) Glazed, insulated, and double walled, with manufacturer's standard metal liner of same material and finish as outer metal lid.

c) Exterior Curb Liner: Manufacturer's standard, of same material and finish as metal curb.

d) Fabricate curbs to minimum height of 12” unless otherwise indicated.

e) Sloping Roofs: Where slope or roof deck exceeds 1:48, fabricate curb with perimeter curb height that is tapered to accommodate roof slope so that top surfaces of perimeter curb are level. Equip hatch with water diverter or cricket on side that obstructs water flow.

7. Hatch-Lid Glazing: Double glazing of thickness capable of resisting indicated loads; white, translucent structured polycarbonate.

8. Hardware: Manufacturer’s standard, corrosion resistant or hot-dip galvanized; with hinges, hold-open devices, and independent manual-release devices for inside and outside operation of lids.

B. Safety Railing System: Provide smoke vent manufacturer’s standard system including rails, clamps, fasteners, and accessories required for a complete installation; attached to smoke vent and complying with 29 CFR 1910.23 requirements and authorities having jurisdiction.

PART 3. EXECUTION

3.01 INSTALLATION

A. General: Verify dimensions of roof openings for roof accessories. Install roof accessories according to manufacturer's written instructions.

1. Install roof accessories level, plumb, true to line and elevation, and without warping, jogs in alignment, excessive oil canning, buckling, or tool marks.

2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.

3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.

4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

C. Seal joints with sealant as required by roof accessory manufacturer.

3.02 REPAIR AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780.

B. Touch up factory-primed surfaces with compatible primer ready for field painting according to Section 099113 “Exterior Painting” and Section 099123 “Interior Painting.”

C. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION 07720

SECTION 07841 - THROUGH-PENETRATION FIRE STOP SYSTEM

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Penetrations in fire-resistance-rated walls.

2. Penetrations in horizontal assemblies.

3. Penetrations in smoke barriers.

1.02 ACTION SUBMITTALS

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

B. Product Schedule: For each penetration fire-stopping system. Include location and design designation of qualified testing and inspecting agency.

1. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration fire-stopping condition, submit illustration, with modifications marked, approved by penetration fire-stopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.03 INFORMATIONAL SUBMITTALS

A. Installer Certificates: From Installer indicating penetration fire-stopping has been installed in compliance with requirements and manufacturer's written recommendations.

B. Product test reports.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

B. Fire-Test-Response Characteristics: Penetration fire-stopping shall comply with the following requirements:

1. Penetration fire-stopping tests are performed by UL.

C. Pre-installation Conference: Conduct conference at Project site.

D. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, through one source from a single manufacturer.

1.05 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Notify Owner's project coordinator at least seven days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by Owner's project coordinator or building inspector, if required by authorities having jurisdiction.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the penetration fire-stopping systems indicated for each application in the Through-Penetration Firestop System Schedule at the end of Part 3 that are produced by one of the following manufacturers:

1. Grace, W. R. & Co. - Conn.

2. Hilti, Inc.

3. Nelson Firestop Products.

4. Specified Technologies Inc.

5. 3M; Fire Protection Products Division.

2.02 FIRE-STOPPING, GENERAL

A. Compatibility: Provide through-penetration firestop systems that are compatible with one another; with the substrates forming openings; and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by through-penetration firestop system manufacturer based on testing and field experience.

B. Accessories: Provide components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Use only components specified by through-penetration firestop system manufacturer and approved by qualified

testing and inspecting agency for firestop systems indicated. Accessories include, but are not limited to, the following items:

1. Permanent forming/damming/backing materials, including the following:

   a) Slag-/rock-wool-fiber insulation.

   b) Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.

   c) Fire-rated form board.

   d) Fillers for sealants.

2. Temporary forming materials.

3. Substrate primers.

4. Collars.

5. Steel sleeves.

2.03 FILL MATERIALS

A. General: Provide through-penetration firestop systems containing the types of fill materials indicated in the Through-Penetration Firestop System Schedule at the end of Part 3 by referencing the types of materials described in this Article. Fill materials are those referred to in directories of referenced testing and inspecting agencies as “fill,” “void,” or “cavity” materials.

B. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

C. Latex Sealants: Single-component latex formulations that after cure do not re-emulsify during exposure to moisture.

D. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

E. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized steel sheet.

F. Intumescent Putties: Non-hardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

G. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

H. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a non-shrinking, homogeneous mortar.

I. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives.

J. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

K. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and non-sag formulation for openings in vertical and other surfaces requiring a non-slumping, gunnable sealant, unless indicated firestop system limits use to non-sag grade for both opening conditions.

2.04 MIXING

A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

2.05 PENETRATION FIRE-STOPPING

A. Provide penetration fire-stopping that is produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration fire-stopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

B. Penetrations in Fire-Resistance-Rated Walls: Ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg

1. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01" wg.

1. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.

2. T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.

D. Penetrations in Smoke Barriers: Provide penetration fire-stopping with ratings determined per UL 1479.

1. L-Rating: Not exceeding 5.0 cfm/sq. ft. (0.025 cu. m/s per sq. m) of penetration opening at 0.30” wg (74.7 Pa) at both ambient and elevated temperatures.

E. Exposed Penetration Fire-stopping: Provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

PART 3. EXECUTION

3.01 INSTALLATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

B. Install penetration fire-stopping to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

C. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-stopping.

D. Install fill materials for fire-stopping by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.

2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.

3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.02 IDENTIFICATION

A. Identify penetration fire-stopping with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6” of fire-stopping edge so labels will be visible to anyone seeking to remove penetrating items or fire-stopping. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words "Warning - Penetration Fire-stopping - Do Not Disturb. Notify Building Management of Any Damage."

2. Contractor’s name, address, and phone number.

3. Designation of applicable testing and inspecting agency.

4. Date of installation.

5. Manufacturer’s name.

6. Installer’s name.

3.03 FIELD QUALITY CONTROL

A. The firestop products manufacturer’s representative shall visit the site a minimum of two times during installation of firestop systems to insure that systems are being properly installed. The firestop manufacturer’s representative shall provide a brief report to the Contractor indicating that materials were being properly installed and/or noting any deficiencies in the installation or use of the firestop systems. The Contractor shall forward one copy of each firestop manufacturer’s report to the Project Coordinator and Architect.

B. Where deficiencies are found or penetration fire-stopping is damaged or removed because of testing, repair or replace penetration fire-stopping to comply with requirements.

C. Proceed with enclosing penetration fire-stopping with other construction only after inspection reports are issued and installations comply with requirements.

3.04 PENETRATION FIRE-STOPPING SCHEDULE

3.05 THROUGH-PENETRATION FIRESTOP SYSTEM SCHEDULE

A. Where UL-classified systems are indicated, they refer to alpha-alpha-numeric designations listed in UL’s “Fire Resistance Directory” under product Category XHEZ.

B. Firestop Systems with No Penetrating Items:

1. Framed Walls-UL-Classified Systems: W-L-0001-0999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Silicone sealant.

c) Intumescent putty.

d) Mortar.

C. Firestop Systems for Metallic Pipes, Conduit, or Tubing:

1. Framed Walls-UL-Classified Systems: W-L-1001-1999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Silicone sealant.

c) Intumescent putty.

d) Mortar

D. Firestop Systems for Nonmetallic Pipe, Conduit, or Tubing

1. Framed Walls-UL-Classified Systems: W-L-2001-2999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Silicone sealant.

c) Intumescent putty.

d) Intumescent wrap strips.

e) Firestop device.

E. Firestop Systems for Electrical Cables

1. Framed Walls-UL-Classified Systems: W-L-3001-3999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Silicone sealant.

c) Intumescent putty.

d) Silicone foam.

e) Pillows/bags.

F. Firestop Systems for Insulated Pipes

1. Framed Walls-UL-Classified Systems: W-L-5001-5999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Intumescent putty.

c) Silicone foam.

d) Intumescent wrap strips.

G. Firestop Systems for Miscellaneous Electrical Penetrants

1. Framed Walls-UL-Classified Systems: W-L-6001-6999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Intumescent putty.

c) Mortar.

H. Firestop Systems for Miscellaneous Mechanical Penetrants

1. Framed Walls-UL-Classified Systems: W-L-7001-7999.

2. Type of Fill Materials: One or both of the following:

a) Latex sealant.

b) Mortar.

I. Firestop Systems for Groupings of Penetrants:

1. Framed Walls-UL-Classified Systems: W-L-3001-3999.

2. Type of Fill Materials: One or more of the following:

a) Latex sealant.

b) Mortar.

c) Intumescent wrap strips.

d) Firestop device.

e) Intumescent composite sheet.

END OF SECTION 07841

SECTION 07842 - FIRE-RESISTIVE JOINT SYSTEMS

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes fire-resistive joint systems for the following:

1. Head-of-wall joints.

2. Wall-to-wall joints.

B. Related Sections include the following:

1. Division 7 Section “Through-Penetration Firestop Systems” for systems installed in openings in walls and floors with and without penetrating items.

2. Division 7 Section “Joint Sealants” for non-fire-resistive joint sealants.

1.02 PERFORMANCE REQUIREMENTS

A. General: Provide fire-resistive joint systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly in which fire-resistive joint systems are installed.

B. Joint Systems in and between Fire-Resistance-Rated Constructions: Provide systems with assembly ratings equaling or exceeding the fire-resistance ratings of construction that they join, with movement capabilities indicated as determined by UL 2079.

C. For fire-resistive systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

1.03 SUBMITTALS

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

B. Shop Drawings: For each fire-resistive joint system, show each kind of construction condition in which joints are installed; also show relationships to adjoining construction. Include fire-resistive joint system design designation of testing and inspecting agency acceptable to authorities having jurisdiction that demonstrates compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each fire-resistive joint system configuration for construction and penetrating items.

C. Product Certificates: For each type of fire-resistive joint system, signed by product manufacturer.

D. Qualification Data: For Installer.

E. At the completion of fire-resistive joint systems installation provide written certification by the fire-resistive joint systems product representative stating that the representative has inspected all locations where fire-resistive joint systems are installed or are required to be installed and the materials, products and systems are installed in accordance with the manufacturer's recommendations and U.L. requirements for that system.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FMG according to FMG 4991, "Approval of Firestop Contractors."

B. Installation Responsibility: Assign installation of through-penetration firestop systems and fire-resistive joint systems in Project to a single qualified installer.

C. Source Limitations: Obtain fire-resistive joint systems, for each kind of joint and construction condition indicated, through one source from a single manufacturer.

D. Fire-Test-Response Characteristics: Provide fire-resistive joint systems that comply with the following requirements and those specified in Part 1 "Performance Requirements" Article:

1. Fire-resistance tests are performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is UL.

2. Fire-resistive joint systems are identical to those tested per methods indicated in Part 1 "Performance Requirements" Article and comply with the following:

a) Fire-resistive joint system products bear classification marking of qualified testing and inspecting agency.

b) Fire-resistive joint systems correspond to those indicated by referencing system designations of the qualified testing and inspecting agency.

3. At the completion of fire-resistive joint systems installation provide written certification by the fire-resistive joint systems product representative stating that the representative has inspected all locations where fire-resistive joint systems are installed or are required to be installed and the materials, products and systems are installed in accordance with the manufacturer's recommendations and U.L. requirements for that system

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver fire-resistive joint system products to Project site in original, unopened containers or packages with qualified testing and inspecting agency's classification marking applicable to Project and with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle materials for fire-resistive joint systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Do not install fire-resistive joint systems when ambient or substrate temperatures are outside limits permitted by fire-resistive joint system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate fire-resistive joint systems per manufacturer's written instructions by natural means or, if this is inadequate, forced-air circulation.

1.07 COORDINATION

A. Coordinate construction of joints to ensure that fire-resistive joint systems are installed according to specified requirements.

B. Coordinate sizing of joints to accommodate fire-resistive joint systems.

C. Notify Owner's project coordinator at least seven days in advance of fire-resistive joint system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up fire-resistive joint system installations that will become concealed behind other construction until Owner's project coordinator and building inspector of authorities having jurisdiction have examined each installation.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the fire-resistive joint systems indicated for each application in the Fire-Resistive Joint System Article

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:

a) Grace, W. R. & Co. - Conn.

b) Hilti, Inc.

c) Nelson Firestop Products.

d) Specified Technologies Inc.

e) 3M; Fire Protection Products Division

2.02 FIRE-RESISTIVE JOINT SYSTEMS

A. Compatibility: Provide fire-resistive joint systems that are compatible with joint substrates, under conditions of service and application, as demonstrated by fire-resistive joint system manufacturer based on testing and field experience.

B. Accessories: Provide components of fire-resistive joint systems, including primers and forming materials, that are needed to install fill materials and to comply with Part 1 “Performance Requirements” Article. Use only components specified by fire-resistive joint system manufacturer and approved by the qualified testing and inspecting agency for systems indicated.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning: Clean joints immediately before installing fire-resistive joint systems to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:

1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of fill materials.

2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with fill materials. Remove loose particles remaining from cleaning operation.

3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by fire-resistive joint system manufacturer using that manufacturer’s recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent fill materials of fire-resistive joint system from contacting adjoining surfaces that will remain exposed on completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from fire-resistive joint system materials. Remove tape as soon as possible without disturbing fire-resistive joint system’s seal with substrates or damaging adjoining surfaces.

3.03 INSTALLATION

A. General: Install fire-resistive joint systems to comply with Part 1 “Performance Requirements” Article and fire-resistive joint system manufacturer's written installation instructions for products and applications indicated.

B. Install forming/packing/backing materials and other accessories of types required to support fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

C. Install fill materials for fire-resistive joint systems by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings and forming/packing/backing materials as required to achieve fire-resistance ratings indicated.

2. Apply fill materials so they contact and adhere to substrates formed by joints.

3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.04 FIELD QUALITY CONTROL

A. The fire-resistive joint systems products manufacturer's representative shall visit the site a minimum of three times during installation of fire-resistive joint systems to insure that systems are being properly installed. The fire-resistive joint systems manufacturer's representative shall provide a brief report to the Contractor indicating that materials were being properly installed and/or noting any deficiencies in the installation or use of the firestop systems. The Contractor shall forward one copy of each firestop manufacturer's report to the Project Coordinator and Architect.

B. Where deficiencies are found, repair or replace fire-resistive joint systems so they comply with requirements.

C. Proceed with enclosing fire-resistive joint systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. At the completion of all fire-resistive joint systems installation, the fire-resistive joint systems manufacturer's representative shall inspect the site and provide written certification stating that all required locations have been fire-stopped and the materials, products and systems are installed in accordance with the manufacturer's recommendations and U.L. requirements for the system.

3.05 CLEANING AND PROTECTING

A. Clean off excess fill materials adjacent to joints as Work progresses by methods and with cleaning materials that are approved in writing by fire-resistive joint system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure fire-resistive joint systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated fire-resistive joint systems immediately and install new materials to produce fire-resistive joint systems complying with specified requirements.

3.06 FIRE-RESISTIVE JOINT SYSTEM SCHEDULE

A. Designation System for Joints in or between Fire-Resistance-Rated Constructions: Alphanumeric systems listed in UL's "Fire Resistance Directory" under Product Category XHBN.

B. Designation System for Joints at the Intersection of Fire-Resistance-Rated Floor or Floor/Ceiling Assembly and an Exterior Curtain-Wall Assembly: Alphanumeric systems listed in UL's "Fire Resistance Directory" under Product Category XHDG:

C. Head-of-Wall Fire-Resistive Joint Systems:

1. UL-Classified Systems: HW-D-0001-0999.

2. Assembly Rating: Maintain original fire-resistance rating of assembly in which joint system is installed.

3. Joint Width: 1-½".

4. Movement Capabilities: Class I.

D. Wall-to-Wall Fire-Resistive Joint Systems:

1. UL-Classified Systems: WW-D-0001-0999.

2. Assembly Rating: Maintain original fire-resistance rating of assembly in which joint system is installed.

a) Joint Width: 1-½".

b) Movement Capabilities: Class I.

END OF SECTION 07842

SECTION 07901 - JOINT SEALANTS

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes joint sealants for the applications indicated in the Joint Sealant Schedule at the end of Part 3, including those specified by reference to this Section.

1.02 PERFORMANCE REQUIREMENTS

A. Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.

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

1.03 SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

C. Product Certificates: Signed by manufacturers of joint sealants certifying that products furnished comply with requirements and are suitable for the use indicated.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has specialized in installing joint sealants similar in material, design, and extent to those indicated for this Project and whose work has resulted in joint-sealant installations with a record of successful in-service performance.

B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multi component materials.

B. Store and handle materials in compliance with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer or are below 40° F.

2. When joint substrates are wet.

B. Joint-Width Conditions: Do not proceed with installation of joint sealants where joint widths are not in compliance with those allowed by joint sealant manufacturer for applications indicated.

C. Joint-Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with adhesion are removed from joint substrates.

PART 2. PRODUCTS

2.01 PRODUCTS AND MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated for each type in the sealant schedules at the end of Part 3.

2.02 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by the A/E from manufacturer's full range for this characteristic.

2.03 ELASTOMERIC JOINT SEALANTS

A. Elastomeric Sealant Standard: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant in the Elastomeric Joint-Sealant Schedule at the end of Part 3, including those referencing ASTM C 920 classifications for type, grade, class, and uses.

B. Additional Movement Capability: Where additional movement capability is specified in the Elastomeric Joint-Sealant Schedule, provide products with the capability, when tested for adhesion and cohesion under maximum cyclic movement per ASTM C 719, to withstand the specified percentage change in the joint width existing at the time of installation and remain in compliance with other requirements of ASTM C 920 for uses indicated.

C. Stain-Test-Response Characteristics: Where elastomeric sealants are specified in the Elastomeric Joint-Sealant Schedule to be non-staining to

porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.

2.04 LATEX JOINT SEALANTS

A. Latex Joint-Sealant Standard: Comply with ASTM C834 for each product of this description indicated in the Latex Joint Sealant Schedule at the end of Part 3.

2.05 JOINT-SEALANT BACKING

A. General: Provide sealant backings of material and type that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

B. Expanded Polyethylene Joint Filler (EPJF): Extruded closed cell polyethylene foam. ASTM D1621, not less than 4 psi for 25 percent compression deflection. ASTM D1623, tensile strength not less than 36 psi. ASTM C509, water absorption not more than 0.1 percent by volume. Non-gassing. Resistant to petroleum oils and solvents. Provide one of the following, as acceptable to the sealant manufacturer.

1. NMC Inc. “Green-Rod”

2. Sonneborn “Sonofoam Closed Cell Backer Rod”

3. Williams Products Inc. “Everlastic Expand-O-Foam”

C. Expanded Neoprene Joint Filler (ENJF): ASTM D1056, Grade SCE41. Extruded closed cell neoprene foam.

1. D.S. Brown Co. “Closed Cell Neoprene”

2. Williams Products Inc. “Everlastic Neoprene Type NN1”

D. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

2.06 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and

adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants with joint substrates.

C. Masking Tape: Non-staining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

2. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining from above cleaning operations by vacuuming or blowing out joints with oil-free compressed air. Porous joint surfaces include the following:

   a) Concrete.

   b) Masonry.

   c) Unglazed surfaces of ceramic tile.

3. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.

   a) Metal.

B. Joint Priming: Prime joint substrates where recommended in writing by joint sealant manufacturer, based on prior experience. Apply primer to comply with

joint sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.03 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations of ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of sealant backings.

2. Do not stretch, twist, puncture, or tear sealant backings.

3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and back of joints.

E. Install sealants by proven techniques to comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.

2. Completely fill recesses provided for each joint configuration.

3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealants from surfaces adjacent to joint.

2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.

3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.

3.04 CLEANING

A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from the original work.

3.06 ELASTOMERIC JOINT-SEALANT SCHEDULE

A. Silicone Sanitary Sealant: Provide products formulated with fungicide that are intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and temperature extremes, and that comply with the following:

1. Products: Provide one of the following:

a) 786 Mildew Resistant; Dow Corning.

b) Sanitary 1700; GE Silicones.

c) 898 Silicone Sanitary Sealant; Pecora Corporation.

d) Tremsil 200; Tremco.

2. Type and Grade: S (single component) and NS (non-sag).

3. Class: 25.

4. Use Related to Exposure: NT (non-traffic).

5. Uses Related to Joint Substrates: G, A, and, as applicable to joint substrates indicated, O.

a) Use O Joint Substrates: Galvanized steel and ceramic tile.

6. Applications: At joints of plumbing fixtures and walls in toilet rooms.

B. Single-Component Neutral-Curing Silicone Sealant:

1. Products:

a) Tremco; Spectrem 3.

b) Dow Corning Corporation; 791.

c) Dow Corning Corporation; 795

d) GE Silicones; UltraPruf II SCS2900.

2. Type and Grade: S (single component) and NS (non-sag).

3. Class: 50.

4. Use Related to Exposure: NT (non-traffic).

5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.

a) Use O Joint Substrates: Aluminum coated with a high-performance coating and galvanized steel.

6. Stain-Test-Response Characteristics: Non-staining to porous substrates per ASTM C 1248.

7. Applications: Wall joints; perimeter of door frames, windows, louvers and like penetrations.

C. 2-Part Polyurethane Modified Sealant: Provide products complying with the following:

1. Products: Provide one of the following:

a) NP 2; Sonneborn Building Products Div., ChemRex Inc.

b) Sikaflex-2cNS; Sika Corporation.

c) Dymeric, Tremco.

2. Type and Grade: M (multi component) and NS (non-sag).

3. Class: 25.

4. Uses Related to Exposure: T (traffic) and NT (non-traffic).

5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.

a) Use O Joint Substrates: Aluminum coated with a high-performance coating, galvanized steel, masonry, ceramic tile, and wood.

6. Applications: Joints in horizontal surfaces.

D. 1-Part Polyurethane Sealant: Provide products complying with the following:

1. Products: Provide one of the following:

   a) Sikaflex - 1a; Sika Corporation.

   b) NP 1; Sonneborn Building Products Div.; ChemRex Inc.

   c) Vulkem 116: Tremco.

2. Type and Grade: S (single component) and NS (non-sag).

3. Class: 25.

4. Uses Related to Exposure: T (traffic) and NT (non-traffic).

5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.

   a) Use O Joint Substrates: color anodic aluminum, galvanized steel, brick, ceramic tile, and wood.

6. Applications: Under exterior door thresholds.

3.07 LATEX JOINT-SEALANT SCHEDULE

A. Latex Sealant: Comply with ASTM C 834, Type P, Grade NF; One part, non-sag, mildew-resistant, sealant formulated to be paintable and recommended for exposed applications on interior involving joint movement of not more than plus or minus 5 percent.

1. Provide one of the following:

   a) Bostik Findley; Chem-Calk 600.

   b) Pecora Corporation; AC-20+

   c) Sonneborn, Division of ChemRex Inc.; Sonolac.

   d) Tremco; Tremflex 834

2. Applications: Interior finish joints, except air seal joints at exterior walls.

3.08 ACOUSTICAL JOINT-SEALANT SCHEDULE

A. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard non-sag, paintable, non-staining latex sealant complying with ASTM C 834 and the following:

1. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

2. Products: Provide one of the following:

a) Pecora Corporation; AC-20 FTR Acoustical and Insulation Sealant.

b) United States Gypsum Co.; SHEETROCK Acoustical Sealant.

B. Applications: At perimeter trim of acoustical ceilings and interior partitions with sound insulation.

END OF SECTION 07901

SECTION 08100 - HOLLOW METAL DOORS AND FRAMES

PART 1. GENERAL

1.01 SUMMARY

A. Section includes the following:

1. Hollow-metal steel doors.

2. Hollow-metal steel door frames.

1.02 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings according to NAAMM-HMMA 803 or SDI A250.8.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include elevations, door edge details, frame profiles, metal thicknesses, preparations for hardware, and other details.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Samples for Verification: For each type of exposed finish required.

E. Schedule: Prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain custom steel doors, frames and windows through one source from a single manufacturer.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver doors, frames and windows palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use non-vented plastic.

1. Provide additional protection to prevent damage to finish of factory-finished doors and frames.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs.

C. Store doors, frames and windows under cover at Project site. Place units in a vertical position with heads up, spaced by blocking, on minimum 4” high, wood blocking. Avoid using non-vented plastic or canvas shelter that could create a humidity chamber.

1. If wrappers on doors become wet, remove cartons immediately. Provide minimum ¼" space between each stacked door to permit air circulation.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Apex Industries, Inc.
2. Ceco Door Products; an Assa Abloy Group company.
3. Curries Company; an Assa Abloy Group company.
4. LaForce, Inc.
5. Steelcraft; an Ingersoll-Rand company.

2.02 REGULATORY REQUIREMENTS

A. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated.

1. Smoke- and Draft-Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Light Assemblies: Complying with NFPA 80 and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.

2.03 INTERIOR DOORS AND FRAMES

A. Heavy-Duty Doors and Frames: ANSI/SDI A250.8/SDI-100, Level 2

1. Physical Performance: Level B according to SDI A250.4.

2. Doors:

   a) Type: As indicated in the Door and Frame Schedule.

   b) Thickness: 1-¾".

   c) Face: Uncoated, unless Metallic-coated (Galvanized) is indicated on door schedule, cold-rolled steel sheet, minimum thickness of 0.060" (16 Ga.).

   d) Edge Construction: Model 2, Seamless.

   e) Core: Vertical steel stiffener extending full door height at max. 6" on center.

3. Frames:

   a) Materials: Uncoated, unless Metallic-coated (Galvanized) is indicated on door schedule, steel sheet, minimum thickness of 0.075" (14 Ga.).

   b) Construction: Face welded.

4. Exposed Finish: Prime.

2.04 EXTERIOR HOLLOW-METAL DOORS AND FRAMES

A. Extra-Heavy-Duty Doors and Frames: ANSI/SDI A250.8/SDI-100, Level 3.

1. Physical Performance: Level A according to SDI A250.4.

2. Doors:

   a) Type: As indicated in the Door and Frame Schedule.

   b) Thickness: 1-¾" (44.5 mm).

   c) Face: Metallic-coated steel sheet, minimum thickness of 0.060" (16 Ga.), with minimum G60 coating in accordance with ASTM A-525, and mill phosphatized to permit paint adhesion

   d) Edge Construction: Model 2, Seamless.

   e) Core: Manufacturer's standard insulation material between vertical steel stiffeners extending full door height at max. 6" on center.

3. Thermal-Rated Doors: Provide doors fabricated with thermal-resistance value (R-value) of not less than R-7 when tested according to ASTM C 1363.

4. Frames:

   a) Materials: Metallic-coated steel sheet, minimum thickness of 0.075” (14 Ga.), with minimum G60 coating in accordance with ASTM A-525.

   b) Construction: Face welded

5. Exposed Finish: Prime

2.05 FRAME ANCHORS

A. Jamb Anchors:

1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042” thick, with corrugated or perforated straps not less than 2” wide by 10” long; or wire anchors not less than 0.177” thick.

2. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042” thick.

3. Post-installed Expansion Type for In-Place Concrete, Masonry or Steel Frame installation: Minimum 3/8” diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

B. Floor Anchors: Formed from same material as frames, minimum thickness of 0.042” and as follows:

1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.

2. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2” height adjustment. Terminate bottom of frames at finish floor surface.

2.06 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

C. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B.

D. Frame Anchors: ASTM A 879/A 879M, Commercial Steel (CS), 04Z (12G) coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

E. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

F. Power-Actuated Fasteners in Concrete: From corrosion-resistant materials.

G. Grout: ASTM C 476, except with a maximum slump of 4”, as measured according to ASTM C 143/C 143M.

H. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing).

I. Glazing: Section 088000 “Glazing.”

J. Bituminous Coating: Cold-applied asphalt mastic, compounded for 15-mil (0.4-mm) dry film thickness per coat.

2.07 FABRICATION

A. Fabricate hollow-metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for metal thickness. Where practical, fit and assemble units in manufacturer’s plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Hollow-Metal Doors:

1. Exterior Doors: Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration. Provide top and bottom channels to close top and bottom edges of exterior doors with channels of same material thickness as face sheets, welded so webs of channels are flush with door edges.

2. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated.

C. Hollow-Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.

1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.

2. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.

3. Floor Anchors: Weld anchors to bottoms of jambs with at least four spot welds per anchor; however, for slip-on drywall frames, provide anchor clips or countersunk holes at bottoms of jambs.

4. Jamb Anchors: Provide number and spacing of anchors as follows:

   a) Masonry Type: Locate anchors not more than 16” from top and bottom of frame. Space anchors not more than 32” o.c., to match coursing, and as follows:

      1) Two anchors per jamb up to 60” high.

      2) Three anchors per jamb from 60 to 90” high.

      3) Four anchors per jamb from 90 to 120” high.

      4) Four anchors per jamb plus one additional anchor per jamb for each 24” or fraction thereof above 120” high.

   b) Stud-Wall Type: Locate anchors not more than 18” from top and bottom of frame. Space anchors not more than 32” o.c. and as follows:

      1) Three anchors per jamb up to 60” high.

      2) Four anchors per jamb from 60 to 90” high.

      3) Five anchors per jamb from 90 to 96” high.

      4) Five anchors per jamb plus one additional anchor per jamb for each 24” or fraction thereof above 96” high.

   c) Post-installed Expansion Type: Locate anchors not more than 6”from top and bottom of frame. Space anchors not more than 26” o.c.

5. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers.

   a) Single-Door Frames: Drill stop in strike jamb to receive three door silencers.

   b) Double-Door Frames: Drill stop in head jamb to receive two door silencers.

D. Hardware Preparation: Factory prepare hollow-metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6, the Door Hardware Schedule, and templates.

1. Reinforce doors and frames to receive non-templated, mortised, and surface-mounted door hardware.

2. Comply with applicable requirements in SDI A250.6 and BHMA A156.115 for preparation of hollow-metal work for hardware.

E. Stops and Moldings: Provide stops and moldings around glazed lites and louvers where indicated. Form corners of stops and moldings with mitered hairline joints.

1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow-metal work.

2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.

3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.

4. Provide loose stops and moldings on inside of hollow-metal work.

5. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.

2.08 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.

1. Shop Primer: SDI A250.10.

2.09 ACCESSORIES

A. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

B. Grout Guards: Formed from same material as frames, not less than 0.016" thick.

PART 3. EXECUTION

3.01 INSTALLATION

A. Hollow-Metal Frames: Install hollow-metal frames of size and profile indicated. Comply with SDI A250.11 or NAAMM-HMMA 840 as required by standards specified.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.

   a) At fire-rated openings, install frames according to NFPA 80.

   b) Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.

   c) Install frames with removable stops located on secure side of opening.

   d) Install door silencers in frames before grouting.

   e) Remove temporary braces necessary for installation only after frames have been properly set and secured.

   f) Check plumb, square, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.

   g) Field apply bituminous coating to backs of frames that will be filled with grout containing antifreezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with post-installed expansion anchors.

   a) Floor anchors may be set with power-actuated fasteners instead of post-installed expansion anchors if so indicated and approved on Shop Drawings.

3. Metal-Stud Partitions: Solidly fill jambs with grout.

4. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.

5. Concrete Walls: Solidly fill space between frames and concrete with grout.

6. In-Place Concrete or Masonry Construction or Steel framed opening: Secure frames in place with post-installed expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.

7. Installation Tolerances: Adjust hollow-metal door frames for squareness, alignment, twist, and plumb to the following tolerances:

   a) Squareness: Plus or minus 1/16” measured at door rabbet on a line 90° from jamb perpendicular to frame head.

   b) Alignment: Plus or minus 1/16”, measured at jambs on a horizontal line parallel to plane of wall.

   c) Twist: Plus or minus 1/16”, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.

   d) Plumbness: Plus or minus 1/16”, measured at jambs at floor.

B. Hollow-Metal Doors: Fit hollow-metal doors accurately in frames, within clearances specified below. Shim as necessary.

1. Non-Fire-Rated Steel Doors:

   a) Between Door and Frame Jambs and Head: 1/8” plus or minus 1/32”.

   b) Between Edges of Pairs of Doors: 1/8” to ¼” plus or minus 1/32”.

   c) At Bottom of Door: 5/8” plus or minus 1/32”.

   d) Between Door Face and Stop: 1/16” to 1/8” plus or minus 1/32”.

2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.

3. Smoke-Control Doors: Install doors and gaskets according to NFPA 105.

C. Glazing: Comply with installation requirements in Section 088000 “Glazing” and with hollow-metal manufacturer’s written instructions.

1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9” o.c. and not more than 2” o.c. from each corner.

3.02 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow-metal work that is warped, bowed, or otherwise unacceptable.

B. Remove grout and other bonding material from hollow-metal work immediately after installation.

C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

D. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

E. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION 08100

SECTION 08330 - INSULATED COILING DOOR

PART 1. GENERAL

1.01 SUMMARY

A. Section includes:

1. Insulated coiling doors.

B. Related Section:

1. Section 05500 “Metal Fabrications” for miscellaneous steel supports.

1.02 PERFORMANCE REQUIREMENTS

A. Structural Performance, Exterior Doors: Exterior overhead coiling doors shall withstand the wind loads, the effects of gravity loads, and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.

1. Wind Loads: Uniform pressure (velocity pressure) of 30 lbf/sq. ft., acting inward and outward.

1.03 ACTION SUBMITTALS

A. Product Data: For each type and size of overhead coiling door and accessory.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer’s product data. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer’s authorized representative who is trained and approved for both installation and maintenance of units required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2. PRODUCTS

2.01 DOOR CURTAIN MATERIALS AND CONSTRUCTION

A. Door Curtains: Fabricate overhead coiling-door curtain of interlocking metal slats, designed to withstand wind loading indicated, in a continuous length for width of door without splices. Unless otherwise indicated, provide slats of thickness and mechanical properties recommended by door manufacturer for performance, size, and type of door indicated, and as follows:

1. Insulation: Fill slats for insulated doors with manufacturer's standard thermal insulation complying with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E 84. Enclose insulation completely within slat faces.

2. Metal Interior Curtain-Slat Facing: Match metal of exterior curtain-slat face.

B. Bottom Bar for Service Doors: Consisting of two angles, each not less than 1-½” by 1-½” by 1/8” thick; fabricated from metal to match curtain slats and finish.

C. Curtain Jamb Guides: Manufacturer’s standard angles or channels and angles of same material and finish as curtain slats unless otherwise indicated, with sufficient depth and strength to retain curtain, to allow curtain to operate smoothly, and to withstand loading. Slot bolt holes for guide adjustment. Provide removable stops on guides to prevent over-travel of curtain.

2.02 HOOD

A. General: Form sheet metal hood to entirely enclose coiled curtain and operating mechanism at opening head. Contour to fit end brackets to which hood is attached. Roll and reinforce top and bottom edges for stiffness. Form closed ends for surface-mounted hoods and fascia for any portion of between-jamb mounting that projects beyond wall face. Equip hood with intermediate support brackets as required to prevent sagging.

2.03 LOCKING DEVICES

A. Chain Lock Keeper: Suitable for padlock.

2.04 CURTAIN ACCESSORIES

A. Weather-seals: Equip each exterior door with weather-stripping gaskets fitted to entire perimeter of door for a weather tight installation, unless otherwise indicated.

B. Push/Pull Handles: Equip each push-up-operated or emergency-operated door with lifting handles on each side of door, finished to match door. Provide pull-down straps or pole hooks for doors more than 84” high.

2.05 COUNTERBALANCING MECHANISM

A. General: Counterbalance doors by means of manufacturer’s standard mechanism with an adjustable-tension, steel helical torsion spring mounted around a steel shaft and contained in a spring barrel connected to top of curtain with barrel rings. Use grease-sealed bearings or self-lubricating graphite bearings for rotating members.

B. Brackets: Manufacturer’s standard mounting brackets of either cast iron or cold-rolled steel plate.

2.06 ELECTRIC DOOR OPERATORS

A. General: Electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and operation-cycles requirement specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking door, and accessories required for proper operation.

1. Comply with NFPA 70.

2. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6, with NFPA 70 Class 2 control circuit, maximum 24 V, ac or dc.

B. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each door.

C. Electric Motors:

1. Electrical Characteristics:

2. Phase: Three Phase.

3. Volts: 208/230/460 (see electrical drawings)

4. Hertz: 60.

5. Motor Type and Controller: Reversible motor and controller (disconnect switch) for motor exposure indicated.

6. Motor Size: Minimum size as indicated. If not indicated, large enough to start, accelerate, and operate door in either direction from any position, at a speed not less than 8”/sec. and not more than 12”/sec. without exceeding nameplate ratings or service factor.

7. Operating Controls, Controllers (Disconnect Switches), Wiring Devices, and Wiring: Manufacturer’s standard unless otherwise indicated.

D. Obstruction Detection Device: Equip motorized door with indicated external automatic safety sensor capable of protecting full width of door opening. For non-fire-rated doors, activation of device immediately stops and reverses downward door travel.

1. Photoelectric Sensor: Manufacturer’s standard system designed to detect an obstruction in door opening without contact between door and obstruction. Provide self-monitoring capability designed to interface with door operator control circuit to detect damage to or disconnection of sensing device.

2. Sensor Edge: Automatic safety sensor edge, located within astragal or weather stripping mounted to bottom bar. Contact with sensor activates device. Connect to control circuit using manufacturer’s standard take-up reel or self-coiling cable. Provide self-monitoring capability designed to interface with door operator control circuit to detect damage to or disconnection of sensing device.

E. Remote-Control Station: Momentary-contact, three-button control station with push-button controls labeled “Open,” “Close,” and “Stop.”

1. Interior units, full-guarded, surface-mounted, heavy-duty type, with general-purpose NEMA ICS 6, Type 1 enclosure.

F. Emergency Manual Operation: Equip each electrically powered door with capability for emergency manual operation. Design manual mechanism so required force for door operation does not exceed 30 lbf .

G. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.

H. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.

2.07 DOOR ASSEMBLY

A. Insulated Coiling-Door: Overhead coiling door formed with curtain of interlocking metal slats.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation – 625 Series Rolling Service Door, or comparable product by one of the following:

2. Cookson Company.

3. Raynor.

4. Wayne-Dalton Corp.

B. Operation Cycles: Not less than 20,000 .

C. Curtain R-Value: 7.7

D. Door Curtain Material: Galvanized steel.

E. Door Curtain Slats: Flat profile slats of 2-5/8" center-to-center height.

F. Insulated-Slat Interior Facing: Metal.

G. Curtain Jamb Guides: Galvanized steel with exposed finish matching curtain slats. Provide continuous integral wear strips to prevent metal-to-metal contact and to minimize operational noise

H. Hood: Match curtain material and finish

1. Shape: Round.

2. Mounting: Face of wall.

I. Locking Devices: Chain lock .

J. Electric Door Operator:

1. Usage Classification: Standard duty, up to 60 cycles per hour.

2. Motor Exposure: Exterior or Interior mounted hood as indicated on the drawings.

3. Emergency Manual Operation: Chain type.

4. Obstruction-Detection Device: Automatic photoelectric sensor and electric sensor edge on bottom bar; self-monitoring type.

5. Remote-Control Station: Interior.

K. Door Finish:

1. Factory Prime Finish: Manufacturer's standard color.

PART 3. EXECUTION

3.01 INSTALLATION

A. Install overhead coiling doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.

B. Fire-Rated Doors: Install according to NFPA 80.

C. Smoke-Control Doors: Install according to NFPA 80 and NFPA 105.

D. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion. Lubricate bearings and sliding parts as recommended by manufacturer. Adjust seals to provide weather tight fit around entire perimeter.

3.02 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain overhead coiling doors.

END OF SECTION 08330

SECTION 08410 - ALUMINUM ENTRANCES AND STOREFRONTS

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Exterior manual-swing entrance door units

1.02 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include plans, elevations, sections, full-size details, and attachments to other work.

1. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

C. Samples: For each exposed finish required.

D. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams.

1.04 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.

1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

1.07 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances and storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

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

PART 2. PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrances and storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Aluminum-framed entrances and storefronts shall withstand movements of supporting structure including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.

2. Failure also includes the following:

a) Thermal stresses transferring to building structure.

b) Glass breakage.

c) Noise or vibration created by wind and thermal and structural movements.

d) Loosening or weakening of fasteners, attachments, and other components.

e) Failure of operating units.

2.02 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer series 500 doors or comparable product by one of the following:

1. Arcadia, Inc.

2. Arch Aluminum & Glass Co., Inc.

3. CMI Architectural.

4. Commercial Architectural Products, Inc.

5. EFCO Corporation.

6. Leed Himmel Industries, Inc.

7. Oldcastle Building Envelope.

8. Pittco Architectural Metals, Inc.

9. TRACO.

10. Tubelite.

2.03 ENTRANCE DOOR SYSTEMS

A. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing operation.

1. Door Construction: 1-3/4" overall thickness, with minimum 0.125"-thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods

a) Thermal Construction for Exterior doors: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.

2. Door Design: Wide stile; 5" nominal width at sides and top and 6-1/2" at the bottom

3. Glazing Stops and Gaskets: Square, snap-on, extruded-aluminum stops and preformed gaskets.

2.04 ENTRANCE DOOR HARDWARE

A. Entrance Door Hardware: Hardware not specified in this Section is specified in Section 08712 "Door Hardware."

B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of entrance door hardware are indicated in "Entrance Door Hardware Sets" Article. Products are identified using entrance door hardware designations as follows:

1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in "Entrance Door Hardware Sets" Article.

2. References to BHMA Standards: Provide products complying with these standards and requirements for description, quality, and function.

C. Butt Hinges: Specified in Section 08712.

D. Closers: Specified in Section 08712.

E. Exit Device and Lockset: Specified in Section 08712.

F. Silencers: BHMA A156.16, Grade 1.

G. Weather Stripping: Manufacturer's standard replaceable components.

H. Weather Sweeps: Manufacturer's standard exterior-door bottom sweep with concealed fasteners on mounting strip.

2.05 GLAZING

A. Glazing: Comply with Section 08800 "Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Glazing Sealants: As recommended by manufacturer.

2.06 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.

2. Accurately fitted joints with ends coped or mitered.

3. Physical and thermal isolation of glazing from framing members.

4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.

5. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

D. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.

E. Entrance Doors: Reinforce doors as required for installing entrance door hardware.

F. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.07 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611 AA-M12C22A31, Class II, 0.010 mm or thicker.

PART 3. EXECUTION

3.01 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.

2. Do not install damaged components.

3. Fit joints to produce hairline joints free of burrs and distortion.

4. Rigidly secure non-movement joints.

5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.

6. Seal perimeter and other joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.

2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Set continuous sill members and flashing in full sealant bed as specified in Section 07901"Joint Sealants" to produce weather tight installation.

D. Install components plumb and true in alignment with established lines and grades.

E. Install operable units level and plumb, securely anchored, and without distortion. Adjust weather-stripping contact and hardware movement to produce proper operation.

F. Install glazing as specified in Section 08800 "Glazing."

G. Entrance Doors: Install doors to produce smooth operation and tight fit at contact points.

1. Exterior Doors: Install to produce weather tight enclosure and tight fit at weather stripping.

2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

3.02 FIELD QUALITY CONTROL

A. Aluminum-framed entrances will be considered defective if they do not pass inspections.

END OF SECTION 08410

SECTION 08452 – INSULATED TRANSLUCENT WALL PANEL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes aluminum-framed assemblies incorporating fiberglass-sandwich panels as follows:

1. Wall assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for aluminum components of panel assemblies.

B. Shop Drawings: For panel assemblies.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include details of provisions for assembly expansion and contraction and for draining moisture within the assembly to the exterior.

C. Samples: In manufacturer's standard size.

1. For each type of fiberglass-sandwich panel.
2. For each type of exposed finish for framing members.

D. Fabrication Samples: Of each framing system intersection and adjacent panels, made from 12-inch lengths of full-size framing members and showing details of the following:

1. Joinery.
2. Anchorage.
3. Fiberglass-sandwich panels.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified manufacturer.

B. Product Test Reports: For each fiberglass-sandwich-panel assembly, for tests performed by a qualified testing agency.

C. Evaluation Reports: For fiberglass-sandwich-panel assemblies from ICC-ES.

D. Sample Warranties: For special warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For panel assemblies to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: For fiberglass-sandwich panels, a qualified manufacturer whose facilities, processes, and products are monitored by an independent, accredited quality-control agency for compliance with applicable requirements in ICC-ES AC04 or ICC-ES AC177.

B. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical panel assemblies as shown on Drawings.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of panel assemblies that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures including, but not limited to, excessive deflection.
   b. Deterioration of metals and other materials beyond normal weathering.
   c. Water leakage.

2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Loads: As indicated on Structural Drawings.

B. Deflection Limits:

1. Vertical Panel Assemblies: Limited to 1/120 of clear span for each assembly component.

C. Structural-Test Performance: Provide panel assemblies tested according to ASTM E 330, as follows:

1. When tested at positive and negative wind-load design pressures, assemblies do not show evidence of deflection exceeding specified limits.

D. Water Penetration under Static Pressure: Provide panel assemblies that do not evidence water penetration through fixed glazing and framing areas when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.

E. Water Penetration under Dynamic Pressure: Provide panel assemblies that do not evidence water leakage through fixed glazing and framing areas when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.

1. Maximum Water Leakage: No uncontrolled water penetrating aluminum-framed systems or water appearing on systems' normally exposed interior surfaces from sources other than condensation. Water leakage does not include water that is controlled by flashing and gutters and drained to the exterior, or water that cannot damage adjacent materials or finishes.

F. Thermal Movements: Allow for thermal movements from ambient- and surface-temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss appropriate to this application.

G. Energy Performance: Provide panel assemblies with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:

1. Thermal Transmittance (U-Factor): Fixed glazing and framing areas shall have U-factor of not more than 0.80 Btu/sq. ft. x h x deg F as determined according to NFRC 100.
2. Solar Heat Gain Coefficient (SHGC): Fixed glazing and framing areas shall have a SHGC of no greater than **0.6** as determined according to NFRC 200.
3. Air Infiltration: Maximum air leakage through fixed glazing and framing areas of 0.30 cfm/sq. ft. of fixed wall area as determined according to ASTM E 283 at a minimum static-air-pressure differential of 1.57 lbf/sq. ft.

2.2 INSULATED TRANSLUCENT WALL PANEL SYSTEMS

A. Insulated Translucent Wall Panel Systems: Translucent assemblies that are supported by aluminum framing and glazed with fiberglass-sandwich panels.

1. Architectural Daylighting
2. Major Industries, Inc.
3. Kalwall Corporation.
4. CPI Daylighting

2.3 FIBERGLASS-SANDWICH PANELS

A. Fiberglass-Sandwich Panels: Uniformly colored, translucent, thermoset, fiberglass-reinforced-polymer face sheets bonded to both sides of a grid core.

1. Core Insulation: Fill panel cores with aerogel.

B. Panel Thickness: 2-3/4 inches.

C. Grid Core: Mechanically interlocked, extruded-aluminum I-beams, with a minimum flange width of 7/16 inch.

1. Extruded Aluminum: ASTM B 221 in alloy and temper recommended in writing by manufacturer.
2. I-Beam Construction: Thermally broken, extruded aluminum.
3. Grid Pattern: Inline rectangle, nominal 12 by 24 inches.

D. Exterior Face Sheet:

1. Thickness: 0.070 inch.
2. Color: As selected by Architect from manufacturer's full range.
3. Protective Weathering Surface: Manufacturer's standard.

E. Interior Face Sheet:

1. Thickness: 0.045 inch (1.14 mm).
2. Color: As selected by Architect from manufacturer's full range.

F. Fiberglass-Sandwich-Panel Adhesive: Manufacturer's standard for permanent adhesion of facings to cores.

G. Panel Strength:

1. Maximum Panel Deflection: 3-1/2 inches (89 mm) when a 4-by-12-foot (1.2-by-3.6-m) panel is tested according to ASTM E 72 at 34 lbf/sq. ft. (1.6 kPa), with a maximum 0.090-inch (2.3-mm) set deflection after five minutes.

2. Panel Support Strength: Capable of supporting, without failure, a 300-lbf (1334-N) concentrated load when applied to a 3-inch- (76-mm-) diameter disk according to ASTM E 661.

H. Panel Performance:

1. Self-Ignition Temperature: 650 deg F (343 deg C) or more according to ASTM D 1929.
2. Smoke-Developed Index: 450 or less according to ASTM E 84, or 75 or less according to ASTM D 2843.
3. Combustibility Classification: Class CC1 based on testing according to ASTM D 635.
4. Interior Finish Classification: Class C based on testing according to ASTM E 84.
5. Color Change: Not more than 3.0 units Delta E, when measured according to ASTM D 2244, after outdoor weathering compliant with procedures in ASTM D 1435.
6. Impact Resistance: No fracture or tear at impact of 60 ft. x lbf (81 J) freefalling ball according to UL 972 test procedure.
7. Haze Factor: Greater than 90 percent when tested according to ASTM D 1003.

2.4 ALUMINUM FRAMING SYSTEMS

A. Components: Manufacturer's standard extruded-aluminum members of thickness required and reinforced as required to support imposed loads.

1. Construction: Thermally broken, extruded aluminum.

B. Aluminum: Alloy and temper recommended in writing by manufacturer for type of use and finish indicated.

1. Sheet and Plate: ASTM B 209.
2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
3. Extruded Structural Pipe and Tubes: ASTM B 429.
4. Structural Profiles: ASTM B 308.

C. Fasteners and Accessories: Manufacturer's standard, corrosion-resistant, nonstaining, and nonbleeding fasteners and accessories; compatible with adjacent materials.

1. At closures, retaining caps, or battens, use ASTM A 193, 300 series stainless-steel screws.
2. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
3. At movement joints, use slip-joint linings, spacers, and sleeves of material and type recommended in writing by manufacturer.

D. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123 or ASTM A 153 requirements.

E. Anchor Bolts: ASTM A 307, Grade A, galvanized steel.

F. Concealed Flashing: Corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.

G. Exposed Flashing and Closures: Aluminum sheet not less than 0.040 inch thick, finished to match framing.

H. Framing Gaskets: Manufacturer's standard.

I. Frame-System Sealants: As recommended in writing by manufacturer.

J. Corrosion-Resistant Coating: Cold-applied asphalt mastic, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.5 FABRICATION

A. Frame System Fabrication:

1. Fabricate components that, when assembled, have the following characteristics:

   a. Profiles that are sharp, straight, and free of defects or deformations.
   b. Accurately fitted joints with ends coped or mitered.
   c. Internal guttering systems or other means to drain water passing through joints, and moisture migrating within assembly to exterior.

2. Fabricate sill closures with weep holes and for installation as continuous component.
3. Reinforce components as required to receive fastener threads.

B. Panel Fabrication: Factory assemble and seal panels.

1. Laminate face sheets to grid core under a controlled process using heat and pressure to produce straight adhesive bonding lines that cover width of core members and that have sharp edges.

   a. White spots indicating lack of bond at intersections of grid-core members are limited in number to four for every 40 sq. ft. (3.7 sq. m) of panel and limited in diameter to 3/64 inch (1.2 mm).

2. Fabricate with grid pattern that is symmetrical about centerlines of each panel.
3. Fabricate panel to allow condensation within panel to escape.
4. Reinforce panel corners.

2.6 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Comply with manufacturer's written instructions.

1. Do not install damaged components.
2. Fit joints between aluminum components to produce hairline joints free of burrs and distortion.
3. Rigidly secure nonmovement joints.
4. Install anchors with separators and isolators to prevent metal corrosion, electrolytic deterioration, and immobilization of moving joints.
5. Seal joints watertight unless otherwise indicated.

B. Metal Protection: Where aluminum components will contact dissimilar materials, protect against galvanic action by painting contact surfaces with corrosion-resistant coating or by installing nonconductive spacers as recommended in writing by manufacturer for this purpose.

C. Install components plumb and true in alignment with established lines and elevations.

D. Erection Tolerances: Install panel assemblies to comply with the following maximum tolerances:

1. Alignment: Limit offset from true alignment to 1/32 inch (0.8 mm) where surfaces abut in line, edge to edge, at corners, or where a reveal or protruding element separates aligned surfaces by less than 3 inches (76 mm); otherwise, limit offset to 1/8 inch (3.2 mm).
2. Location and Plane: Limit variation from true location and plane to 1/8 inch in 12 feet (3.2 mm in 3.7 m), but no greater than 1/2 inch (13 mm) over total length.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

1. Water-Spray Test: Before installation of interior finishes has begun, panel assemblies shall be tested according to AAMA 501.2 and shall not show evidence of water penetration.
2. Water Penetration under Static Pressure: Before installation of interior finishes has begun, areas shall be tested according to ASTM E 1105.

a. Test Procedures: Test under uniform and cyclic static-air pressure.
b. Water Penetration: None.

B. Repair or remove work where test results and inspections indicate that it does not comply with specified requirements.

C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

END OF SECTION 08452

SECTION 08620 – UNIT SKYLIGHTS

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes factory-assembled unit skylights for installation in flat roof areas.

1. Type: Self flashing with integral curb and safety railing system.

2. Glazing: Acrylic

B. Related Sections include the following:

1. Division 6 Section “Rough Carpentry for wood framing and blocking at unit skylights.”

1.02 PERFORMANCE REQUIREMENTS

A. Structural Loads: Provide unit skylights, including glazing and anchorage, capable of withstanding the effects of the following design loads:

1. Snow Load: As indicated on structural drawings

2. Negative Pressure (Uplift) Load: As indicated on structural drawings and as required by local code requirements.

1.03 SUBMITTALS

A. Product Data: For unit skylights. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For unit skylights. Include plans, elevations, sections, details, and attachments to other Work.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Samples for Verification: For each type of exposed finish required, in a representative section of each unit in manufacturer's standard size.

1.04 QUALITY ASSURANCE

A. Fire-Test Response Characteristics of Plastic Glazing: Provide plastic glazing sheets identical to those tested for fire-exposure behavior per test method indicated below by a testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

1. Self-Ignition Temperature: 650° F (343° C) or greater for plastic sheets in thickness indicated when tested per ASTM D 1929.

2. Smoke Production Characteristics: Comply with either requirement below:

   a) Smoke-Developed Index: 450 or less when tested per ASTM E 84 on plastic sheets in manner indicated for use.

   b) Smoke Density: 75 or less when tested per ASTM D 2843 on plastic sheets in thickness indicated for use.

3. Relative-Burning Characteristics: Tested per ASTM D 635.

   a) Acrylic Glazing: Class CC2, burning rate of 2.5” per minute or less for nominal thickness of 0.060” or thickness indicated for use.

   b) Polycarbonate Glazing: Class CC1, burning extent of 1” or less for nominal thickness of 0.060” or thickness indicated for use.

1.05 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of unit skylights that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, the following:

1. Uncontrolled water leakage.

2. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

3. Yellowing of acrylic glazing.

B. Warranty Period: Five years from Substantial Completion.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design: Skylights shall be Carlisle’s Drylight Skylight as manufactured by Carlisle Syntec, Greenville, IL.

B. Available Products: Subject to compliance with requirements, products from manufacturers that may be incorporated into the Work include, but are not limited to, the following:

1. American Skylites Inc.

2. Auburn Skylights, Major Industries, Inc.

3. Bristolite Skylights.

4. Kalwall Corporation.

5. Traco, Skytech Systems, Inc.

6. Wasco Products, Inc.

7. CPI Daylighting

2.02 UNIT SKYLIGHTS

A. General: Factory-assembled units that include glazing, extruded-aluminum glazing retainers, gaskets, and inner frames and that are capable of withstanding design loads indicated.

B. Integral Curb: Self-flashing type.

1. Height: 5’ radius (90 degree low profile).

2. Insulation: Manufacturer’s standard rigid type.

C. Unit Shape and Size: 8’ wide by 28’ inside curb (coordinate exact sizes with working drawings).

D. Acrylic Glazing: ASTM D 4802, thermoformable, monolithic sheet, Category as standard with manufacturer, Type UVA (formulated with UV absorber), Finish 1 (smooth or polished).

1. Double-Glazing Profile: Dome, 25 percent rise

a) Outer Glazing Color: Colorless, transparent

b) Inner Glazing Color: Colorless, transparent

E. Glazing Gaskets: Manufacturer’s standard

F. Aluminum Components:

1. Sheets: ASTM B 209 (ASTM B 209M), alloy and temper to suit forming operations and finish requirements but with not less than the strength and durability of alclad alloy 3005-H25.

2. Extruded Shapes: ASTM B 221 (ASTM B 221M), alloy and temper to suit structural and finish requirements but with not less than the strength and durability of alloy 6063-T52.

3. Anodic Coating: Class I, color anodic coating complying with AAMA 611.

a) Color: As selected by Architect from manufacturer’s full range

G. Fasteners: Same metal as metal being fastened, nonmagnetic stainless steel, or other noncorrosive metal as recommended by manufacturer. Finish exposed fasteners to match material being fastened.

H. Condensation Control: Fabricate unit skylights with integral internal gutters and nonclogging weeps to collect and drain condensation to the exterior.

I. Thermal Break: Fabricate unit skylights with thermal barrier separating interior metal framing from materials exposed to outside temperature.

J. Protective Screens: Manufacturer's standard to protect personnel from falls.

K. Safety Railing System: Provide skylight manufacturer's standard system including rails, clamps, fasteners, and accessories required for a complete installation; safety railing system shall comply with 29 CFR 1910.23 requirements and authorities having jurisdiction.

2.03 INSTALLATION MATERIALS

A. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic, nominally free of sulfur and containing no asbestos fibers, formulated for 15-mil (0.4-mm) dry film thickness per coating.

B. Mastic Sealant: Polyisobutylene; nonhardening, nonskinning, nondrying, nonmigrating sealant.

C. Elastomeric Sealant: STM C 920; Type S; Grade NS; Class 25; and Uses NT, G, A, and (as applicable to joint substrates indicated) O; recommended by unit skylight manufacturer and compatible with joint surfaces.

D. Roofing Cement: ASTM D 4586, asbestos free, designed for trowel application or other adhesive compatible with roofing system.

PART 3. EXECUTION

3.01 INSTALLATION

A. Coordinate unit skylight installation with installation of substrates, vapor retarders, roof insulation, roofing, and flashing as required to ensure that each element of the Work performs properly and that combined elements are waterproof and weathertight.

1. Unless otherwise indicated, install unit skylights according to construction details of NRCA's "The NRCA Roofing and Waterproofing Manual."

B. Where metal surfaces of units will contact incompatible metal or corrosive substrates, including wood, apply bituminous coating on concealed metal surfaces, or provide other permanent separation recommended in writing by unit skylight manufacturer.

C. Anchor unit skylights securely to supporting substrates.

D. Set unit skylight flanges in thick bed of roofing cement to form a seal, unless otherwise indicated.

E. Where cap flashing is indicated, install to produce waterproof overlap with roofing or roof flashing. Seal with thick bead of mastic sealant except where overlap is indicated to be left open for ventilation.

3.02 CLEANING

A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

1. Operating Units: Clean and lubricate joints and hardware. Adjust for proper operation.

END OF SECTION 08620

SECTION 08712 - DOOR HARDWARE

PART 1. GENERAL

1.01 SUMMARY

A. Section includes:

1. Mechanical door hardware for the following:

a) Swinging doors.

2. Permanent lock cores to be installed by Owner.

1.02 RELATED WORK

A. The following sections prescribe items of work. Coordinated work prescribed by this section with work prescribed by the following sections:

1. Section “08100 Hollow Metal Doors and Frames.”

2. Section “08410 Aluminum Entrances, Storefronts and Windows.”

1.03 ACTION SUBMITTALS

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

B. Samples: For each exposed product and for each color and texture specified.

C. Other Action Submittals:

1. Door Hardware Schedule: Prepared by or under the supervision of Installer, detailing fabrication and assembly of door hardware, as well as installation procedures and diagrams. Coordinate final door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

a) Format: Use same scheduling sequence and format and use same door numbers as in the Contract Documents.

b) Content: Include the following information:

1) Identification number, location, hand, fire rating, size, and material of each door and frame.

2) Locations of each door hardware set, cross-referenced to Drawings on floor plans and to door and frame schedule.

3) Complete designations, including name and manufacturer, type, style, function, size, quantity, function, and finish of each door hardware product.

4) Description of electrified door hardware sequences of operation and interfaces with other building control systems.

5) Keying Schedule: Prepared by or under the supervision of Installer, detailing Owner's final keying instructions for locks.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Supplier of products and an employer of workers trained and approved by product manufacturers and an Architectural Hardware Consultant who is available during the course of the Work to consult with Contractor, Architect, and Owner about door hardware and keying.

B. Architectural Hardware Consultant Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.

C. Source Limitations: Provide electrified door hardware from same manufacturer as mechanical door hardware, unless otherwise indicated. Manufacturers that perform electrical modifications and that are listed by a testing and inspecting agency acceptable to authorities having jurisdiction are acceptable.

D. Fire-Rated Door Assemblies: Where fire-rated door assemblies are indicated, provide door hardware rated for use in assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C, unless otherwise indicated.

E. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that meet requirements of assemblies tested according to UL 1784 and installed in compliance with NFPA 105.

F. Means of Egress Doors: Latches do not require more than 15 lbf to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.

G. Accessibility Requirements: For door hardware on doors in an accessible route, comply with ICC/ANSI A117.1

1. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf.

2. Comply with the following maximum opening-force requirements:

a) Interior, Non-Fire-Rated Hinged Doors: 5 lbf applied perpendicular to door.

b) Fire Doors: Minimum opening force allowable by authorities having jurisdiction.

3. Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than ½" high.

4. Adjust door closer sweep periods so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3” from the latch, measured to the leading edge of the door.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

B. Deliver keys and permanent cores to Owner by registered mail or overnight package service.

1.06 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion, unless otherwise indicated.

a) Exit Devices: Two years from date of Substantial Completion.

b) Manual Closers: 10 years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 HARDWARE MATERIALS AND FABRICATION

A. Produce hardware units of the basic metal indicated, using the manufacturer’s standard metal alloy, composition, temper and hardness and with the finish specified. Use the manufacturer's standard production method for the class or quality of hardware units required.

B. Fasteners: Manufacture hardware to conform to published templates, generally prepared for machine screw installation. Do not provide hardware which has been prepared for self-tapping sheet metal screws, except as specifically indicated.

1. Furnish screws for installation, with each hardware item. Provide tamperproof flat head screws except as otherwise indicated. Furnish tamperproof stainless steel screws for the attachment of all hardware items.

2. Furnish sufficient screws with each item to prevent delay in case of loss or damage in installing screws.

3. Provide concealed fasteners for hardware units which are exposed when the door is closed, except to the extent no standard manufactured units of the type specified are available which concealed fasteners. Do not use through bolts for installation where the bolt head or the nut on the

exposed face is exposed except where it is not possible to adequately reinforce the work and use machine screws or concealed fasteners of another standard type.

4. Provide fasteners which are compatible with both the unit fastened and the substrate, and which will not cause corrosion or deterioration of hardware, base material or fastener.

5. Fiber, wood or iron expansion shields for installing hardware items are not acceptable. Use lead anchors or molley or toggle bolts, whichever is appropriate.

C. Hand of Door: The Drawings show the swing or hand of each door leaf (left, right, reverse bevel, etc.). Furnish each item of hardware for proper installation and operation of the door swing as shown.

2.02 HARDWARE FINISHES

A. General

1. Match the finish of every hardware unit at each door or opening, to the greatest extent possible. Reduce differences in color and textures as much as commercially possible where the base metal or metal forming process is different for individual units of hardware exposed at the same door or opening. In general, match all items to the manufacturer's standard finish or the latch and lock set (or push-pulls units if no latch-lock sets) for color and texture.

2. A/E’s representative will be the sole judge of whether hardware units match each other satisfactorily. Units will be judged when 2’-0” apart at 3’-0” distance.

3. Provide finishes that match those established by BHMA.

B. Standard Finish Designations: The designations used in schedules and elsewhere to indicate hardware finishes are those established by the Builders Hardware Manufacturers Association usually abbreviated BHMA, except where US number designations are used. Following is a list of BHMA finishes cross referenced to US numbers.

BHMA CODE	FINISH DESCRIPTION	NEAREST U.S. EQUIVALENT
600	Prime Coat Paint (steel base)	US P
626	Brushed Chrome (brass/bronze base)	US 26 D
628	Brushed Aluminum, Anodized	US 28
630	Brushed Stainless Steel	US 32 D

652	Brushed Chrome (steel base)	US 26 D
689	Finish Coat Paint (steel base aluminum color)	

Specific Hardware Material Requirements

C. While the hardware list is intended to cover all door and other movable parts of the building and establish a type and standard of quality, it shall be the specific duty and responsibility of the finish hardware supplier to examine the Drawings and Specification and furnish proper hardware for all openings whether listed or not. If there are any omissions in hardware listing in regard to regular doors, they shall be called to the attention of the owner prior to award of contract.

D. Items of hardware not definitely specified herein, excepting hardware excluded above, but necessary for completion of the work shall be provided. Such items shall be of type and quality suitable to the service required and comparable to the adjacent hardware. Where size and shape of members is such as to prevent the use of types specified, hardware shall be furnished of suitable types having as nearly as practicable the same operation and quality as the type specified. Sizes shall be adequate for the service required.

2.03 SCHEDULED DOOR HARDWARE

A. Provide door hardware for each door as scheduled on Drawings to comply with requirements in this Section.

1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products equivalent in function and comparable in quality to named products or products complying with BHMA designations referenced.

2.04 HINGES

A. Meet requirements of ANSI/ BHMA A156.1.

B. Finish: 630.

C. Meet requirements of ANSI A156.1

D. Include the following options:

1. Heavy duty ball bearing hinges.

2. Full mortise butt type.

3. Five (5) knuckle design.

4. Stainless steel non-rising pins.

5. Non-removable pins (NRP) on reverse bevel doors to be locked.

E. Sizes: Furnish quantity, size and gauge as recommended by the Manufacturer subject to the following minimum requirements:

1. Height of Hinges

a) For doors 36” wide or less 4-1/2” height.

b) For doors over 36” to 48” wide – 5” height.

c) For doors over 48” wide – 6” height.

2. Width of Hinges

a) For hinge height up to 5” high - 4 ½” width.

b) For hinge height of 5” high and over – 5” width.

3. Number of Hinges

a) Doors 60” high or less – 2.

b) Over 60” not over 90”– 3.

c) Over 90” not over 120” – 4.

d) 1 hinge for each 30” over 120”.

F. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Hager Companies.

2. IVES Hardware; an Ingersoll-Rand company.

3. McKinney Products Company; an ASSA ABLOY Group company.

4. Stanley Commercial Hardware; Div. of The Stanley Works.

2.05 MECHANICAL LOCKS AND LATCHES

A. Strikes: Provide manufacturer’s standard strike for each lock bolt or latch-bolt complying with requirements indicated for applicable lock or latch and with strike box and curved lip extended to protect frame; finished to match lock or latch.

1. Flat-Lip Strikes: For locks with three-piece antifriction latch-bolts, as recommended by manufacturer.

2. Aluminum-Frame Strike Box: Manufacturer’s special strike box fabricated for aluminum framing.

B. Basis of Design: Stanley Best “9K Series,” with interchangeable 7-pin core, series 15D Lever style as manufactured by Sargent Division of Assa Abloy.

C. Lock Type: Heavy Duty cylindrical Locks ANSI/BHMA A156.2; Series 4000 Operational Grade 1; stamped steel case with steel or brass parts.

D. General Requirements:

1. Locks and trim must be of the same Manufacturer and must conform to requirements of ANSI 156.5.

2. Levers on doors to stairs, mechanical rooms and other hazardous areas must be knurled and comply with the requirements of ANSI A117.1.

3. Finish: 626.

E. Levers: Solid Cast Lever L section stainless steel, “contour angle return” style, fully ADA compliant.

F. Trim: 3-3/8” diameter rose.

G. Function: As indicated in hardware schedule and cross-referenced to ANSI No. as follows:

1. Office: F109.

2. Privacy: F76.

3. Entrance: F109.

4. Storage/Storeroom: F86.

5. Classroom: F84

H. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Adams Rite Manufacturing Co.; an Assa Abloy Group company.

2. Corbin Russwin Architectural Hardware; an Assa Abloy Group company.

3. Schlage Commercial Lock Division; an Ingersoll-Rand company.

4. Yale Security Inc.; an Assa Abloy Group company.

2.06 EXIT DEVICES

A. General: Provide rim type push-bar exit devices unless specified otherwise. Provide Fire rated exit devices on rated doors.

B. Meet requirements for BHMA A156.3, Grade 2.

C. Accessibility Requirements: Where handles, pulls, latches, locks, and other operating devices are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" and ANSI A117.1.

1. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22 N).

D. Exit Devices for Means of Egress Doors: Comply with NFPA 101. Exit devices shall not require more than 15 lbf (67 N) to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.

1. Fire Exit Devices: Devices complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252.

E. Outside Trim: as called for in hardware set; material and finish to match locksets, unless otherwise indicated.

F. Dogging: Provide cylinder dogging where indicated on the drawings.

G. Finish: 630.

H. Available Manufacturers, subject to compliance with requirements above:

1. Corbin Russwin Architectural Hardware; an Assa Abloy Group company (CR).

2. Adams Rite Manufacturing Co. (ARM).

3. Yale Commercial Locks and Hardware; an Assa Abloy Group company (YAL).

4. Von Duprin; an Ingersoll-Rand Company (VD).

5. SARGENT Manufacturing Company; an Assa Abloy Group company (SGT).

2.07 DOOR CLOSERS

A. General:

1. Meet requirements for grade 1 closers in accordance with ANSI A 156.4.

2. All closers shall have delayed action, opening force and closing speed as required by ANSI A117.1.

3. Mounting Side: Install on inside of building for exterior doors and on inside of rooms unless noted otherwise.

4. When the term “closer” is used in hardware set without any qualification as to type, it shall be understood to mean door face mounted exposed type.

5. Provide all closers by the same manufacturer.

6. Provide closers with heavy duty arms, cast iron body and any plates, brackets, supports, adapters or other accessories as required for complete installation.

B. Basis of Design: LCN 4040 Series by LCN Closers of Princeton, IL.

C. Size of closer must be manufacturer’s recommendations consistent with warranty.

D. Construction:

1. Full rack and pinion type.

2. Metal covers.

3. Cast iron body.

4. Heat treating steel working parts.

5. All-weather fluids.

E. Provide integral stops and holders as called for on the drawings. Integral stops shall be of spring-cushioned kind. Do not provide holders on fire rated doors.

F. Design of closers must be modern type with metal cover.

G. Unless otherwise indicated, mount closers on side of door away from corridors and public areas. Mount closers on inside of exterior doors. Provide parallel-arm door closers as required.

H. Finish: 689.

I. Available Manufacturers, subject to compliance with requirements above:

1. Corbin/Russwin, Berlin, CT 06037.

2. LCN Closers, Princeton, IL 61356.

3. Norton Door Controls, Charlotte, NC 28229.

4. Sargent Manufacturing Co., New Haven, CT 06511.

2.08 DOOR PROTECTION PLATES

A. Meet requirements of ANSI A156.6

B. Category J100 door protection plates:

1. Beveled four edges.

2. Thickness: 0.050 inch stainless steel.

3. Finish: 630 (US 32D).

4. Type J102 kick plate, 10” high.

5. Type J103 mop plate, 4” high.

6. Half-height protection plate: 34” high.

7. For push side of door, 1½” less than door width.

8. For pull side of door, 1” less than door width.

C. Available Manufacturers, subject to compliance with requirements above:

1. Hager Companies, St. Louis, MO 63104.

2. Hiawatha Inc., Bloomington, MN 55435.

3. H.B. Ives Manufacturing Co., Wallingford, CT 06492.

4. Rockwood Manufacturing Co., Rockwood, PA 15557.

2.09 DOOR STOPS

A. General: Provide a stop for each door unless specifically indicated otherwise by a note, “no stops required”. Stops must conform to the following:

1. Overhead stops and holders must meet requirements for ANSI A156.8.

2. Finish: 630

3. Wall stops must meet requirement of ANSI A 156.16.

4. Where wall conditions permit and stop can contact with lever, use wall type bumper L02101.

5. Where a wall type bumper cannot be used, furnish overhead stop/holder ANSI type 156.8 CO2511 or CO2541 at fire-rated doors: Concealed, heavy duty, hold-open and stop, hold-open function on or off by control knob, adjustable tension on hold-open.

6. Finish: 630. All tamperproof stainless steel screws and attachments. Include fillers, brackets and all options required to coordinate with surface mounted closers. Holder set to 95º if conditions permit.

7. Available Manufacturers, subject to compliance with requirements above:

a) Overhead Stop/Holders
   1) Glynn-Johnson, Indianapolis, IN 46219.
   2) Yale Security, Inc., Charlotte, NC 28229.
   3) Sargent Manufacturing Co., New Haven, CT 06511.

b) Wall bumpers
   1) Glynn-Johnson, Indianapolis, IN 46219.
   2) Hager Companies, St. Louis, MO 63104.
   3) Hiawatha Inc., Bloomington, MN 55435.

2.10 WEATHERSTRIPPING AND DOOR SEALS

A. Weather-stripping must conform to the following:

1. Must be furnished on all exterior doors.
2. Stainless steel retainer with neoprene insert.
3. One of the following Products will be acceptable:
   a) Zero Weather-stripping Company - #328.
   b) Pemko - # 319.
   c) Reese - #403.

B. Exterior Threshold must conform to the following:

1. Must be furnished on all exterior doors.
2. Finish: Satin nickel anodized aluminum .
3. Provide slip resistant, non-skid surface.
4. Provide full thermal break at exterior doors.
5. One of the following Products will be acceptable:
   a) Zero Weather-stripping Company - #626.
   b) Pemko - # 253X3AFG
   c) Reese - #S473A

C. Interior Thresholds must conform to the following:

1. Finish: Satin nickel anodized aluminum .
2. Provide slip resistant, non-skid surface.

3. Provide full with of door frame, cut to fit around door stop.

4. Provide beveled edges at max. slope of 2H:1V.

5. Products from the following Manufacturers are acceptable subject to compliance with requirements:

   a) Zero Weather-stripping Company.

   b) Pemko

   c) Reese

D. Rain Drips must conform to the following:

1. Must be furnished on all exterior doors.

2. Anodized Aluminum rain drip mounted on outside of door above door.

   a) Basis of Design: Reese – R201A.

3. Products from the following Manufacturers are acceptable subject to compliance with requirements:

   a) Zero Weather-stripping Company

   b) Pemko

E. Door Bottom Sweep must conform to the following:

1. Must be furnished on all exterior doors.

2. Stainless steel retainer with neoprene insert.

3. Basis of Design: Pemko - # 323A.

4. Products from the following Manufacturers are acceptable subject to compliance with requirements:

   a) Zero Weather-stripping Company.

   b) Reese.

F. Smoke Seal must conform to the following:

1. Must conform to UL 1784 for Air Leakage Test of Door Assemblies.

2. Finish: Anodized Aluminum.

3. Must not interfere with door closer and other door hardware.

4. Basis of Design: Pemko - # 2891P.

5. Products from the following Manufacturers are acceptable subject to compliance with requirements:

    a) Zero Weather-stripping Company.

    b) Reese.

2.11 MISCELLANEOUS HARDWARE

A. Door Silencers must conform to the following:

1. Three (3) for each single door

2. Two (2) for each pair of doors.

3. None required on doors with smoke seals or weather-stripping.

4. One of the following Manufacturers will be acceptable:

    a) Glynn-Johnson, Indianapolis, IN 46219.

    b) Hager Companies, St. Louis, MO 63104.

    c) Hiawatha Inc. Bloomington, MN 55435.

B. Latch Protector must conform to the following:

1. Stainless steel.

2. Size: 1-1/2” x 10” – 0.105” thick for mortise type locks.

3. Through bolted, tamperproof on outside.

4. One of the following Manufacturers will be acceptable:

    a) McKinney Hinge, an Assa Abloy Company.

    b) Or approved equal.

2.12 LOCK CYLINDERS

A. Cylinders: BEST 7-pin small format interchangeable Core capable of master keying, construction keying and adaptable to existing keying system on site.

B. Construction Keying: Comply with the following:

1. Construction Cores: Provide construction cores that are replaceable by permanent cores. Provide 10 construction master keys.

    a) Furnish only temporary construction cores for the construction period and remove these when directed by the owner.

b) Owner will furnish and install final cores and keys.

2.13 KEYING

A. All keying will be handled by owner.

2.14 FABRICATION

A. Fasteners: Provide door hardware manufactured to comply with published templates prepared for machine, wood, and sheet metal screws. Provide screws that comply with commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.

1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.

2. Fire-Rated Applications:

a) Wood or Machine Screws: For the following:

1) Hinges mortised to doors or frames; use threaded-to-the-head wood screws for wood doors and frames.

2) Strike plates to frames.

3) Closers to doors and frames.

b) Steel Through Bolts: For the following unless door blocking is provided:

1) Surface hinges to doors.

2) Closers to doors and frames.

3) Surface-mounted exit devices.

3. Spacers or Sex Bolts: For through bolting of hollow-metal doors.

4. Fasteners for Wood Doors: Comply with requirements in DHI WDHS.2, “Recommended Fasteners for Wood Doors.”

5. Gasketing Fasteners: Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

2.15 FINISHES

A. Provide finishes complying with BHMA A156.18 as indicated in door hardware schedule.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3. EXECUTION

3.01 INSTALLATION

A. Steel Doors and Frames: For surface applied door hardware, drill and tap doors and frames according to ANSI/SDI A250.6.

B. Mounting Heights: Mount door hardware units at heights to comply with the following unless otherwise indicated or required to comply with governing regulations.

1. Standard Steel Doors and Frames: ANSI/SDI A250.8.

2. Custom Steel Doors and Frames: HMMA 831.

3. Wood Doors: DHI WDHS.3, “Recommended Locations for Architectural Hardware for Wood Flush Doors.”

C. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work. Do not install surface-mounted items until finishes have been completed on substrates involved.

1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.

2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

D. Hinges: Install types and in quantities indicated in door hardware schedule but not fewer than the number recommended by manufacturer for application indicated or one hinge for every 30” (750 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.

E. Lock Cylinders: Install construction cores to secure building and areas during construction period.

1. Replace construction cores with permanent cores as directed by Owner.

2. Furnish permanent cores to Owner for installation.

F. Thresholds: Set thresholds for exterior doors and other doors indicated in full bed of sealant complying with requirements specified in Section 079200 “Joint Sealants.”

G. Stops: Provide floor stops for doors unless wall or other type stops are indicated in door hardware schedule. Do not mount floor stops where they will impede traffic.

H. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

I. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

J. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

K. Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

3.02 FIELD QUALITY CONTROL

A. Independent Architectural Hardware Consultant: Owner will engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.

END OF SECTION 08712

SECTION 08810 - GLAZING

PART 1. GENERAL

1.01 SUMMARY

A. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:

1. Windows.

2. Doors.

3. Glazed curtain walls.

4. Glazed entrances.

1.02 PERFORMANCE REQUIREMENTS

A. General: Provide glazing systems capable of withstanding normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, and installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

B. Glass Design: Glass thickness designations indicated are minimums and are for detailing only. Confirm glass thicknesses by analyzing Project loads and in-service conditions. Provide glass lites in the thickness designations indicated for various size openings, but not less than thicknesses and in strengths (annealed or heat treated) required to meet or exceed the following criteria:

1. Glass Thicknesses: Select minimum glass thicknesses to comply with ASTM E 1300, according to the following requirements:

a) Specified Design Wind Loads: 90 mph

b) Specified Design Wind Loads: 30psf but not less than wind loads applicable to Project as required by ASCE 7 “Minimum Design Loads for Buildings and Other Structures”: Section 6.0 “Wind Loads.”

c) Design Wind Loads: Determine design wind loads applicable to Project from basic wind speed indicated in miles per hour at 30 feet above grade, according to ASCE 7, “Minimum Design Loads for Buildings and Other Structures”: Section 6.5, "Method 2-Analytical Procedure," based on mean roof heights above grade indicated on Drawings.

1) Basic Wind Speed: 90 mph.

2) Importance Factor: I=1.0.

3) Exposure Category: C.

d) Maximum Lateral Deflection: For the following types of glass supported on all 4 edges, provide thickness required that limits center deflection at design wind pressure to 1/50 times the short side length or 1” whichever is less.

1) For monolithic-glass lites heat treated to resist wind loads.

2) For insulating glass.

3) For laminated-glass lites.

e) Thickness of Tinted and Heat-Absorbing Glass: Provide the same thickness for each tint color indicated throughout Project.

C. Thermal Movements: Provide glazing that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures acting on glass framing members and glazing components. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 180° F material surfaces.

D. Thermal and Optical Performance Properties: Provide glass with performance properties specified based on manufacturer's published test data, as determined according to procedures indicated below:

1. For monolithic-glass lites, properties are based on units with lites 6.0 mm thick

2. For laminated-glass lites, properties are based on products of construction indicated.

3. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.

4. Center-of-Glass Values: Based on using LBL-44789 WINDOW 5.0 computer program for the following methodologies:

a) U-Factors: NFRC 100 expressed as Btu/ sq. ft. x h x deg F

b) Solar Heat Gain Coefficient: NFRC 200.

c) Solar Optical Properties: NFRC 300.

1.03 PRECONSTRUCTION TESTING

A. Preconstruction Adhesion and Compatibility Testing: Test each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.

1. Testing will not be required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.

1.04 ACTION SUBMITTALS

A. Product Data: For each glass product and glazing material indicated.

B. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

C. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

1. For solar-control low-e-coated glass, provide documentation demonstrating that manufacturer of coated glass is certified by coating manufacturer.

D. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

1.05 INFORMATIONAL SUBMITTALS

A. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

1. For solar-control low-e-coated glass, provide documentation demonstrating that manufacturer of coated glass is certified by coating manufacturer.

B. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed glazing similar in material, design, and extent to that indicated for this Project; whose work has resulted in glass installations with a record of successful in-service performance; and who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.

B. Glazing for Fire-Rated Door Assemblies: Glazing for assemblies that comply with NFPA 80 and that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252.

C. Safety Glazing Products: Comply with testing requirements in 16 CFR 1201 and, for wired glass, ANSI Z97.1.

1. Subject to compliance with requirements, obtain safety glazing products permanently marked with certification label of the Safety Glazing Certification Council or another certification agency.

2. Where glazing units, including Kind FT glass are specified in Part 2 articles for glazing lites 9 sq. ft. or less in exposed surface area of one side, provide glazing products that comply with Category I or II materials, except for hazardous locations where Category II materials are required by 16 CFR 1201 and regulations of authorities having jurisdiction.

D. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.

E. For solar-control low-e-coated glass, provide documentation demonstrating that manufacturer of coated glass is certified by coating manufacturer.

F. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. GANA Publications: GANA's "Glazing Manual."

1.07 WARRANTY

A. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer's standard form in which coated-glass manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.

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

B. Manufacturer's Special Warranty on Laminated Glass: Manufacturer's standard form in which laminated-glass manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.

1. Warranty Period: 5 years from date of Substantial Completion.

C. Manufacturer's Special Warranty on Insulating Glass: Manufacturer's standard form in which insulating-glass manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of

insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.

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

PART 2. PRODUCTS

2.01 GLASS PRODUCTS, GENERAL

A. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.

B. Strength: Where float glass is indicated, provide annealed float glass, Kind HS heat-treated float glass, or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article. Where heat-strengthened glass is indicated, provide Kind HS heat-treated float glass or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article. Where fully tempered glass is indicated, provide Kind FT heat-treated float glass.

C. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:

1. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F

2. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.

3. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

2.02 GLASS PRODUCTS

A. Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I (clear) unless otherwise indicated.

B. Heat-Strengthened Float Glass: ASTM C 1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.

C. Fully Tempered Float Glass: ASTM C 1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

2.03 LAMINATED GLASS

A. Laminated Glass: ASTM C 1172. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.

1. Construction: Laminate glass with polyvinyl butyral interlayer to comply with interlayer manufacturer's written instructions.

2. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.

3. Interlayer Color: Clear unless otherwise indicated.

2.04 INSULATING GLASS

A. Insulating-Glass Units, General: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, and complying with ASTM E 774 for Class CBA units and with requirements specified in this Article and in Part 2 “Insulating-Glass Units” Article.

1. Provide Kind HS (heat-strengthened) float glass in place of annealed glass where needed to resist thermal stresses induced by differential shading of individual glass lites and to comply with glass design requirements specified in Part 1 “Performance Requirements” Article.

2. Provide Kind FT (fully tempered) glass lites where safety glass is indicated.

3. Overall Unit Thickness and Thickness of Each Lite: Dimensions indicated for insulating-glass units are nominal and the overall thicknesses of units are measured perpendicularly from outer surfaces of glass lites at unit's edge.

4. Sealing System: Dual seal, with primary and secondary sealants as follows:

a) Manufacturer’s standard sealants.

5. Spacer Specifications: Manufacturer’s standard spacer material and construction.

2.05 GLAZING GASKETS

A. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from one of the following:

1. Neoprene complying with ASTM C 864.

2. EPDM complying with ASTM C 864.

3. Silicone complying with ASTM C 1115.

4. Thermoplastic polyolefin rubber complying with ASTM C 1115.

B. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned neoprene, EPDM, silicone, or thermoplastic polyolefin rubber gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.

1. Application: Use where soft compression gaskets will be compressed by inserting dense compression gaskets on opposite side of glazing or pressure applied by means of pressure-glazing stops on opposite side of glazing.

2.06 GLAZING SEALANTS

A. General:

1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.

2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.

3. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range.

B. Glazing Sealants for Fire-Rated Glazing Products: Products that are approved by testing agencies that listed and labeled fire-resistant glazing products with which they are used for applications and fire-protection ratings indicated.

2.07 MISCELLANEOUS GLAZING MATERIALS

A. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

B. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

C. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.

D. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).

E. Cylindrical Glazing Sealant Backing: ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

F. Perimeter Insulation for Fire-Resistive Glazing: Product that is approved by testing agency that listed and labeled fire-resistant glazing product with which it is used for application and fire-protection rating indicated.

2.08 MONOLITHIC-GLASS TYPES

A. Glass Type GL-1 (Glazing in doors and sidelights): Clear fully tempered float glass.

1. Thickness: 6.0 mm (1/4”).
2. Provide safety glazing labeling.

2.09 INSULATING-GLASS TYPES

A. Glass Type GL-2: Low-e-coated, tinted insulating glass (Grey)

1. Overall Unit Thickness: 1”.
2. Thickness of Each Glass Lite 6.0 mm (1/4”).
3. Outdoor Lite: fully tempered coated and tinted float glass.
4. Interspace Content: Air.
5. Indoor Lite: fully tempered clear float glass.
6. Basis of Design: Pilkington Eclipse Advantage (Solar Control Low-E) – Grey
7. Color: Grey
8. Low-E Coating: Pyrolytic or sputtered on second surface.
9. Visible Light Transmittance: 29 percent minimum.
10. Winter Nighttime U-Factor: 0.35 maximum.
11. Summer Daytime U-Factor: 0.35 maximum.
12. Solar Heat Gain Coefficient: 0.33 maximum.

PART 3. EXECUTION

3.01 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

G. Provide spacers for glass lites where length plus width is larger than 50”.

H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

3.02 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place

against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

F. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.03 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weather tight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weather tight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

3.04 SEALANT GLAZING (WET)

A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.

B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.

C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

3.05 CLEANING AND PROTECTION

A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances

do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.

C. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.

D. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

END OF SECTION 08810

SECTION 08911 - ALUMINUM FRAMED CURTAIN WALL SYSTEM

PART 1. GENERAL

1.01 SUMMARY

A. Section includes glazed aluminum curtain walls.

1.02 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project Site.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include plans, elevations, sections, full-size details, and attachments to other work.

1. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

C. Samples: For each exposed finish required.

D. Delegated-Design Submittal: For glazed aluminum curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Aluminum curtain wall system shall withstand code required loads and additional loads indicated to support the exterior canopy.

1.04 INFORMATIONAL SUBMITTALS

A. Energy Performance Certificates: NFRC-certified energy performance values from manufacturer.

B. Product test reports.

C. Field quality-control reports.

D. Sample warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of

assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.

1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

1.07 WARRANTY

A. Special Assembly Warranty: Manufacturer agrees to repair or replace components of glazed aluminum curtain wall that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

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

PART 2. PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with performance requirements specified, as determined by testing of glazed aluminum curtain walls representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Glazed aluminum curtain walls shall withstand movements of supporting structure including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.

2. Failure also includes the following:

a) Thermal stresses transferring to building structure.

b) Glass breakage.

c) Noise or vibration created by wind and thermal and structural movements.

d) Loosening or weakening of fasteners, attachments, and other components.

e) Failure of operating units.

B. Structural Loads:

1. Wind Loads: As required by IBC2009 and ASCE 7.

2. Canopy Loads: As indicated on drawings

C. Deflection of Framing Members: At design wind pressure, as follows:

1. Deflection Normal to Wall Plane: Limited to edge of glass in a direction perpendicular to glass plane not exceeding 1/175 of the glass edge length for each individual glazing lite or an amount that restricts edge deflection of individual glazing lites to 3/4", whichever is less.

2. Deflection Parallel to Glazing Plane: Limited to 1/360 of clear span or 1/8", whichever is smaller.

D. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:

1. Temperature Change: 120° F ambient; 180° F, material surfaces.

2.02 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer 1600 Wall System 1 or comparable product by one of the following:

1. Arcadia, Inc.

2. Arch Aluminum & Glass Co., Inc.

3. Bruce Wall Systems Corporation.

4. CMI Architectural.

5. EFCO Corporation.

6. Pittco Architectural Metals, Inc.

7. Shuco USA LP.

8. Tingwall Inc.

9. TRACO.

10. United States Aluminum.

11. Unitized Systems LLC.

12. Waltek & Company Limited.

2.03 FRAMING

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Construction: Thermally broken

2. Glazing System: Retained mechanically with gaskets on four sides.

3. Glazing Plane: Front.

4. Finish: Clear anodic finish.

5. Fabrication Method: Either factory- or field-fabricated system.

B. Pressure Caps: Manufacturer's standard aluminum components that mechanically retain glazing.

1. Include snap-on aluminum trim that conceals fasteners.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with non-staining, nonferrous shims for aligning system components.

D. Curtain wall system manufacturer to provide entrance door framing with flush door adapter to receive exterior aluminum storefront entrance door per specification Section 08410.

E. Materials:

1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

a) Sheet and Plate: ASTM B 209.

b) Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221

c) Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.

d) Structural Profiles: ASTM B 308/B 308M.

2. Steel Reinforcement: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM, and prepare surfaces according to applicable SSPC standard.

a) Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.

b) Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.

c) Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

2.04 GLAZING

A. Glazing: Comply with Section 08800 “Glazing.”

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Glazing Sealants: As recommended by manufacturer.

2.05 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.

2. Accurately fitted joints with ends coped or mitered.

3. Physical and thermal isolation of glazing from framing members.

4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.

5. Provisions for field replacement of glazing from exterior.

6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

7. Provisions for Entrance door framing with flush door adapter.

D. Fabricate components to resist water penetration as follows:

1. Internal guttering system or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

2. Pressure-equalized system or double barrier design with primary air and vapor barrier at interior side of glazed aluminum curtain wall and secondary seal weeped and vented to exterior.

E. Factory-Assembled Frame Units:

1. Rigidly secure non-movement joints.

2. Prepare surfaces that are in contact structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion.

3. Preparation includes, but is not limited to, cleaning and priming surfaces.

4. Seal joints watertight unless otherwise indicated.

5. Install glazing to comply with requirements in Section 08800 “Glazing.”

F. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.06 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.

PART 3. EXECUTION

3.01 INSTALLATION

A. General:

1. Comply with manufacturer’s written instructions.

2. Do not install damaged components.

3. Fit joints to produce hairline joints free of burrs and distortion.

4. Rigidly secure non-movement joints.

5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.

6. Where welding is required, weld components in concealed locations to minimize distortion or discoloration of finish. Protect glazing surfaces from welding.

7. Seal joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with primer, applying sealant or tape, or installing nonconductive spacers as recommended by manufacturer for this purpose.

2. Where aluminum is in contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 08800 “Glazing.”

END OF SECTION 08911

SECTION 09260 - GYPSUM BOARD ASSEMBLIES

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Non-load-bearing steel framing members for gypsum board assemblies.
2. Gypsum board for gypsum board partitions and ceilings
3. Accessories for installation and trimming of gypsum board.
4. Gypsum board soffit assemblies.
5. Shaft-wall enclosures
6. Chase enclosures

1.02 DEFINITIONS

A. Gypsum Board Terminology: Refer to ASTM C 11 for definitions of terms for gypsum board assemblies not defined in this Section or in other referenced standards.

1.03 SUBMITTALS

A. Product Data: Manufacturer's technical data for each type of product specified.

B. Accessories: Manufacturer’s technical data for each accessory type used.

1.04 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction

1. Fire-Resistance-Rated Assemblies: Indicated by design designations from UL's "Fire Resistance Directory."

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.

B. Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Stack gypsum panels flat to prevent sagging.

C. Handle gypsum board to prevent damage to edges, ends and surfaces. Do not bend or damage metal corner beads and trim.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

B. Ventilation: Ventilate building spaces, as required, for drying joint treatment materials. Avoid drafts during hot dry weather to prevent finishing materials from drying too rapidly.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Steel Framing and Furring:
   a) Clark Steel Framing Systems.
   b) Consolidated Systems, Inc.
   c) Dietrich Industries, Inc.

2. Gypsum Board and Related Products:
   a) G-P Gypsum.
   b) National Gypsum Company.
   c) USG Corporation.

2.02 STEEL SUSPENDED SOFFIT FRAMING

A. Components, General: Comply with ASTM C 754 for conditions indicated

B. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.0625 inch diameter wire, or double strand of 0.0475 inch diameter wire.

C. Hanger Attachments to Concrete: As follows:

1. Anchors: Fabricated from corrosion-resistant materials with holes or loops for attaching hanger wires and capable of sustaining, without failure, a load equal to 5 times that imposed by construction as determined by testing according to ASTM E 488 by a qualified independent testing agency.
2. Powder-Actuated Fasteners: Suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other devices for attaching hangers of type indicated, and capable of sustaining, without failure, a load equal to10 times that imposed by construction as determined by testing according to ASTM E 1190 by a qualified independent testing agency.

D. Hangers: As follows:

1. Wire Hangers: ASTM A641, Class 1 zinc coating, soft temper, 0.162 diameter.

E. Furring Channels (Furring Members): Commercial-steel sheet with ASTM A653, G40, hot-dip galvanized zinc coating.

1. Steel Studs: ASTM C645.
   a) Minimum Base Metal Thickness: 0.0329 inches
   b) Depth: As indicated on drawings.
2. Hat-shaped, rigid furring channels: ASTM C645 - 7/8 inch deep
   a) Minimum Base Metal Thickness: 0.0329 inch.

2.03 STEEL PARTITION FRAMING

A. Components, General: As follows:

1. Comply with ASTM C754 for conditions indicated.
2. Steel Sheet Components: Complying with ASTM C645 requirements for metal and with ASTM A653/A, G60, hot-dip galvanized zinc coating.

B. Steel Studs and Runners: ASTM C645.

1. Minimum Base metal Thickness: 0.0329 inch, unless otherwise shown
2. Depth: As indicated on drawings.

C. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

1. Minimum Base Metal Thickness: 0.0329 inch

D. Hat-Shaped, Rigid Furring Channels: ASTM C645.

1. Minimum Base Metal Thickness: 0.0329 inch.

2. Depth: 7/8 inch.

E. Furring Brackets: Serrated arm type, adjustable, fabricated from corrosion resistant steel sheet complying with ASTM C 645, minimum thickness of base (uncoated) metal of 0.0329 inch, designed for screw attachment to steel studs and steel rigid furring channels used for furring.

F. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

2.04 INTERIOR GYPSUM WALLBOARD

A. General: Complying with ASTM C 36 or ASTIM C 1396, as applicable to type of gypsum board indicated and whichever is more stringent.

B. Panel Size: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.

C. Gypsum Wallboard: ASTM C 36.

D. Regular Type:

1. Thickness: 5/8 inch.
2. Long Edges: Tapered.

E. Ceiling Type: Manufactured to have more sag resistance than regular-type gypsum board. – Use Water Resistant Glass-Mat Board in Washroom ceilings and soffits.

1. Thickness: 5/8 inch.
2. Long Edges: Tapered.

F. Fire-Resistive Type: ASTM C36, having improved fire resistance over standard Type X.

1. Products: Subject to compliance with requirements, provide one of the following:
   a) American Gypsum Co.: FireBlock Type C
   b) National Gypsum Company: Gold Bond Fire-Shield G
   c) United States Gypsum Co.: SHEETROCK Brand Gypsum Panels, FIRECODE C Core.
   d) G-P Gypsum.
2. Thickness: 5/8 inch
3. Long Edges: Tapered.

G. Water Resistant Glass-Mat Board: With moisture and mold resistant core, glass mat facing on both side of panel, type x.

1. Mold Resistance: ASTM D 3273; no mold growth after four weeks exposure.
2. Thickness: As indicated on drawings.
3. Product: Georgia-Pacific DensGuard Tile Backer

H. Impact Resistant Gypsum Board: Moisture-resistant, noncombustible dense gypsum core with a strong layer of embedded mesh with abuse-resistant coated fiberglass mats.

1. Mold Resistance: ASTM D 3273;
2. Thickness: As indicated on drawings.
3. Product: Georgia-Pacific DensArmor Plus Impact-Resistant Interior Panel.

2.05 GYPSUM SHAFTWALL PANEL PRODUCTS

A. Gypsum Liner Panels: Comply with ASTM C 442/C 442M.

1. Type X: Manufacturer's proprietary liner panels with moisture-resistant paper faces.
   a) Core: 1 inch thick.
   b) Long Edges: Double bevel.

2. Moisture-and Mold-Resistant Type X: Manufacturer's proprietary liner panels with moisture-and mold-resistant core and surfaces; comply with ASTM D 3273.
   a) Core: 1 inch thick.
   b) Long Edges: Double bevel.

B. Gypsum Board: As specified in Division 09 Section "Gypsum Board."

C. Water-Resistant Gypsum Backing Board: As specified in Division 09 Section "Gypsum Board."

2.06 GYPSUM BOARD SHAFT-WALL ASSEMBLIES

A. Fire-Resistance Rating: As indicated.

B. STC Rating: As indicated.

C. Studs: Manufacturer's standard profile for repetitive members, corner and end members, and fire-resistance-rated assembly indicated.

1. Depth: As indicated.
2. Minimum Base Metal Thickness: Manufacturer's standard thicknesses that comply with structural performance requirements for stud depth indicated.

D. Runner Tracks: Manufacturer's standard J-profile track with long-leg length as standard with manufacturer, but at least 2 inches long and in depth matching studs.

1. Minimum Base Metal Thickness: Thickness based on structural capabilities tabulated in manufacturer's literature and on Project conditions, but no less than 20-gauge base metal thickness.

E. Jamb Struts: Manufacturer's standard J-profile strut with long-leg length of 3 inches, in depth matching studs.

F. Cavity Insulation: Sound attenuation blankets, where indicated on drawings.

2.07 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.

1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
2. Shapes:
   a) Corner bead: Use at outside corners.
   b) Bullnose Bead: Use at outside corners.
   c) LC-Bead: J-shaped; exposed long flange receives joint compound; use at exposed panel edges.
   d) L-Bead: L-shaped; exposed long leg receives joint compound; use where indicated.

e) U-Bead: J-shaped; exposed short flange does not receive joint compound; use at exposed panel edges.
f) Other shapes as shown on drawings.

2.08 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475.

B. Joint Tape:

1. Interior Gypsum Wallboard: Paper reinforcing tape.
2. Tile Backer Units: Polymer coated, open glass fiber mesh tape

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

1. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.
   a) Use setting-type compound for installing paper-faced metal trim accessories.
3. Fill Coat: For second coat, use setting-type, sandable topping compound.
4. Finish Coat: For third coat, use setting-type, sandable topping compound.

D. Joint Compound for Cementitious Backer Unit: Material recommended by cementitious backer unit manufacturer.

2.09 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written recommendations.

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

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.

C. Sound Attenuation Blankets: ASTM C 665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.

1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

D. Acoustical Sealant for Exposed and Concealed Joints: Non-sag, paintable, non-staining, latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission through perimeter joints and openings in building

construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Products:
   a) OSI Sealants, Inc.; Pro-Series, SC 175 Acoustical Sound Sealant Non-Flammable-Latex.
   b) Pecora Corporation; AC-20 + Silicone.
   c) Tremco Incorporated; Tremflex 834.
   d) United States Gypsum Co.; SHEETROCK Acoustical Sealant.

E. Backer Plates: 20 gauge steel plate, 6 inches wide, G 60 hot dip galvanized coating complying with ASTM A 525, length as required for fastening to studs and to provide support for wall mounted work.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLING STEEL FRAMING, GENERAL

A. Installation Standards: ASTM C 754, and ASTM C 840 requirements that apply to framing installation.

1. Isolate ceiling assemblies where they abut or are penetrated by building structure.

B. Install supplementary framing, blocking, and bracing at terminations in gypsum board assemblies to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction. Comply with details indicated and with gypsum board manufacturer's written recommendations or, if none available, with United States Gypsum's "Gypsum Construction Handbook."

3.03 INSTALLING STEEL SUSPENDED CEILING AND SOFFIT FRAMING

A. Suspend ceiling hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or ceiling suspension system. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, counters playing, or other equally effective means.
2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with the location of hangers required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or

equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.

3. Secure wire hangers by looping and wire-tying, either directly to structures or to inserts, eyes crews, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail.
4. Secure rod or angle hangers to structure, including intermediate framing members, by attaching to inserts, eyes crews, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not connect or suspend steel framing from ducts, pipes, or conduit.

B. Installation Tolerance: Install steel framing components for suspended ceilings so members for panel attachment are level to within 1/8 inch in 20 feet measured lengthwise on each member and transversely between parallel members

C. Sway-brace suspended steel framing.

D. Wire-tie or clip furring channels to supports, as required to comply with requirements for assemblies indicated.

E. Install suspended steel framing components in sizes and spaces indicated, but not less than that required by the referenced steel framing and installation standards.

1. Wire Hangers: 0.1620 inch (8 gauge) diameter, maximum 4 feet o.c. in direction of main runner channels, at right angles to main runners, and within 6 inches of ends of main runner ends and of boundary wall, girders, and interruptions in ceiling continuity..
2. Carrying Channels (Main Runners): 1-1/2 inch, 4 feet o.c. Do not allow main runner in contact with abutting masonry walls. Locate runner channels within 6 inches of walls to support ends of furring channels.
3. Rigid Furring Channels (Furring Members): 16 inches o.c. Do not allow contact with masonry walls. Provide end splices by nesting channels of studs minimum 8 inches and wire tire securely.
4. Furring Channel Clips: Install on alternate sides of main runner channels. Wire tie metal furring channel to 1-1/2 inch channel when clips cannot be alternated and to main support members.

F. Grid Suspension System: Attach perimeter wall track or angle where grid suspension system meets vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

3.04 INSTALLING STEEL PARTITION FRAMING

A. Install tracks (runners) at floors, ceilings, and structural walls and columns where gypsum board assemblies abut other construction:

B. Installation Tolerance: Install each steel framing and furring member so fastening surfaces vary not more than 1/8 inch from the plane formed by the faces of adjacent framing.

C. Sway-brace suspended steel framing.

D. Extend partition framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.

1. Cut studs 1 inch short of full height to provide perimeter relief.
2. For fire-resistance-rated partitions that extend to the underside of floor/roof slabs and decks or other continuous solid-structure surfaces to obtain ratings, install framing around structural and other members extending below floor/roof slabs and decks, as needed to support gypsum board closures and to make partitions continuous from floor to underside of solid structure.

E. Install steel studs and furring at the following spacings:

1. Single-Layer Construction: 16 inches o.c., unless otherwise indicated
2. Multi-Layer Construction: 16 inches o.c., unless otherwise indicated.

F. Install steel studs so flanges point in the same direction and leading edge or end of each panel can be attached to open (unsupported) edges of stud flanges first.

G. Frame door openings to comply with GA-600 and with gypsum board manufacturer's applicable written recommendations, unless otherwise indicated. Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.

1. Install two studs at each jamb, unless otherwise indicated.
2. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint.
3. Extend jamb studs through suspended ceilings and attach to underside of floor or roof structure above

H. Frame openings other than door openings the same as required for door openings, unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.

3.05 INSTALLING GYPSUM SHAFT WALL

A. General: Install gypsum board shaft-wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated, manufacturer's written installation instructions, and the following:

1. ASTM C 754 for installing steel framing except comply with framing spacing indicated.
2. Division 09 Section "Gypsum Board" for applying and finishing panels.

B. Do not bridge architectural or building expansion joints with shaft-wall assemblies; frame both sides of expansion joints with furring and other support.

C. Install supplementary framing in gypsum board shaft-wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, and similar items that cannot be supported directly by shaft-wall assembly framing.

1. At elevator hoistway entrance door frames, provide jamb struts on each side of door frame.
2. Where handrails directly attach to gypsum board shaft-wall assemblies, provide galvanized steel reinforcing strip with 0.0312-inch minimum thickness of base (uncoated) metal, accurately positioned and secured behind at least 1 face-layer panel.

D. Integrate stair hanger rods with gypsum board shaft-wall assemblies by locating cavity of assemblies where required to enclose rods.

E. At penetrations in shaft wall, maintain fire-resistance rating of shaft-wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons, elevator floor indicators, and similar items.

F. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels, while maintaining continuity of fire-rated construction.

G. Install control joints to maintain fire-resistance rating of assemblies.

H. Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly. Install acoustical sealant to withstand dislocation by air-pressure differential between shaft and external spaces; maintain an airtight and smoke-tight seal; and comply with ASTM C 919 requirements or with manufacturer's written instructions, whichever are more stringent.

I. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

3.06 APPLYING AND FINISHING PANELS, GENERAL

A. Gypsum Board Application and Finishing Standards: ASTM C 840 and GA-216.

B. Install sound attenuation blankets before installing gypsum panels, unless blankets are readily installed after panels have been installed on one side.

1. Install sound attenuation blankets over tops of partitions where partitions are indicated less than full height and include sound attenuation blankets in the partition. Extend blankets horizontally 4 feet on both sides of partitions.
2. Sound attenuation partitions: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Close off sound-flanking paths around or through partitions, including sealing partitions above acoustical ceilings.

C. For soffits, install ceiling board panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in the central area of each soffit. Stagger abutting end joints of adjacent panels not less than one framing member.

D. Install gypsum panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.

E. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends.

F. Attach gypsum panels to steel studs so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

G. Attach gypsum panels to framing provided at openings and cutouts.

H. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's written recommendations.

3.07 PANEL APPLICATION METHODS

A. Single-Layer Application:

1. On ceilings, apply gypsum panels at right angles to framing, unless otherwise indicated.
2. On partitions/walls, apply gypsum panels vertically (parallel to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
   a) Stagger abutting end joints not less than one framing member in alternate courses of board.

b) At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.

B. Multilayer Application on Partitions/Walls: Apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions

C. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.

D. Multilayer Fastening Methods: Fasten base layers and face layers separately to supports with screws

3.08 INSTALLING TRIM ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Install corner beads at external corners.

C. Install edge trim where edge of gypsum panels would otherwise be exposed or semi exposed. Provide edge trim type with face flange formed to receive joint compound except where other types are indicated.

1. Install LC bead where gypsum panels are tightly abutted to other construction and back flange can be attached to framing or supporting substrate.
2. Install L bead where edge trims can only be installed after gypsum panels are installed.
3. Install U bead where indicated.
4. Install aluminum trim and other accessories where indicated.

D. Control Joints: Install control joints according to ASTM C 840 and in specific locations approved by the Owner Representatives for visual effect

3.09 FINISHING GYPSUM BOARD ASSEMBLIES

A. General: Treat gypsum board joints, interior angles, edge trim, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints and damaged surface areas.

C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840.

1. Level 1: Ceiling plenum areas, concealed areas, and where indicated, unless a higher level of finish is required for fire resistive rated assemblies and sound rated assemblies
2. Level 4: All panel surfaces exposed to view; embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges at panel surfaces that will be exposed to view, unless otherwise indicated

3.10 CLEANING AND PROTECTION

A. Promptly remove any residual joint compound from adjacent surfaces.

B. Provide final protection and maintain conditions, in a manner suitable to Installer, that ensures gypsum board assemblies remain without damage or deterioration at time of Substantial Completion.

C. Prior to installation of ceiling, stencil fire rating of each rated partition above ceiling line. Stencil rating every 10 feet using permanent paint

END OF SECTION 09260

SECTION 09300 - CERAMIC TILE

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Ceramic tile.
2. Waterproof membrane.
3. Crack isolation membrane.
4. Metal edge strips and Thresholds.
5. Ceramic Tile Wall Base

1.02 ACTION SUBMITTALS

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

B. Samples:

1. Each type and composition of tile and for each color and finish required.
2. Assembled samples, with grouted joints, for each type and composition of tile and for each color and finish required.

1.03 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering and identified with labels describing contents.

1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.

1.04 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockup of each type of floor tile installation.
2. Build mockup of each type of wall tile installation.
3. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2. PRODUCTS

2.01 TILE PRODUCTS

A. ANSI Ceramic Tile Standard: Provide Standard grade tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.

B. FloorScore Compliance: Tile for floors shall comply with requirements of FloorScore Standard.

C. Tile Type PS: Glazed paver tile.

1. Basis-of-Design Product:

   a) Floor Tile – 12”x12” Daltile Continental Slate Porcelain Floor Tile – color as indicated on drawings.

   b) Wall Base – 6”x12” Daltile Continental Slate Porcelain Floor Tile wall base – color as indicated on drawings.

2. Subject to compliance with requirements, provide comparable product by one of the following:

   a) American Marazzi Tile, Inc.

   b) American Olean; Division of Dal-Tile International Inc.

   c) Florida Tile.

   d) Crossville Tile.

3. Thickness: 5/16” for Daltile Continental Slate Porcelain Floor Tile.

4. Face: Pattern of design indicated, with square edges.

5. Tile Pattern: As indicated on the drawings.

6. Grout Color: Laticrete, color: 24 Natural Gray.

7. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as required, selected from manufacturer’s standard shapes.

2.02 THRESHOLDS

A. General: Provide metal tile threshold per manufacturer's standard.

1. Limit height of threshold to adjacent floor surface.

2. Description: As selected by owner's representative if required.

2.03 CRACK ISOLATION MEMBRANE

A. General: Manufacturer's standard product, that complies with ANSI A118.12 for high performance and is recommended by the manufacturer for the application indicated.

B. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.

1. Products: Subject to compliance with requirements, provide one of the following:

a) Custom Building Products; Redgard Waterproofing and Crack Prevention Membrane

b) Southern Grouts & Mortars, Inc.; Southcrete 1100 Crack Suppression and Waterproofing.

c) TEC, a subsidiary of H. B. Fuller Company; HydraFlex - Waterproofing Crack Isolation Membrane.

d) Mapei, Aquadefense – Waterproofing Crack Isolation Membrane.

2.04 SETTING MATERIALS

A. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.

1. Basis-of-Design Product: Subject to compliance with requirements, provide "Mapei – UltraContact Mortar for floors and Mapei UltraLight Mortar for walls" or comparable product by one of the following:

a) Boiardi Products; a QEP company.

b) Bonsal American; an Oldcastle company.

c) Bostik, Inc.

d) C-Cure.

e) Custom Building Products.

f) Jamo Inc.

g) Laticrete International, Inc.

h) MAPEI Corporation.

i) Mer-Kote Products, Inc.

j) Southern Grouts & Mortars, Inc.

k) Summitville Tiles, Inc.

l) TEC; a subsidiary of H. B. Fuller Company.

2. For wall applications, provide non-sagging mortar.

2.05 GROUT MATERIALS

A. Polymer-Modified Tile Grout: ANSI A118.7.

1. Basis-of-Design Product: Subject to compliance with requirements, provide “Mapei Keracolor S Premium sanded Grout with polymer and Van Hurren Grout-Once additive” or comparable product by one of the following:

a) Boiardi Products; a QEP company.

b) Bonsal American; an Oldcastle company.

c) Bostik, Inc.

d) C-Cure.

e) Custom Building Products.

f) Laticrete International, Inc.

g) MAPEI Corporation.

h) TEC; a subsidiary of H. B. Fuller Company.

2.06 MISCELLANEOUS MATERIALS

A. Trowelable Underlayments and Patching Compounds: Latex-modified, Portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Metal Edge Strips where required: Angle or L-shape, stainless steel, ASTM A 666, 300 Series exposed-edge material.

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

a) Blanke Corporation.

b) Ceramic Tool Company, Inc.

c) Schluter Systems L.P.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.

1. Verify that substrates for setting tile are firm, dry, clean, free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.

3.02 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with thin-set mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4” per foot toward drains.

C. Blending: For tile exhibiting color variations, use factory blended tile or blend tiles at Project site before installing.

D. Field-Applied Temporary Protective Coating: If indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.03 INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.

1. For the following installations, follow procedures in the ANSI A108 Series of tile installation standards for providing 95 percent mortar coverage:

a) Tile floors in wet areas.

b) Tile floors composed of tiles 8" by 8" or larger.

c) Tile floors composed of rib-backed tiles.

B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.

E. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated. As much as possible, use full tiles at areas exposed to view and locate partial tiles at areas screened or hidden under equipment and fixtures.

F. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:

1. Floor Tile: 3/16".

G. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

H. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.

1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.

2. Prepare joints and apply sealants to comply with requirements in Section 079200 “Joint Sealants.”

I. Metal Edge Strips: Install where exposed edge of tile flooring meets carpet, wood, or other flooring that finishes flush with or below top of tile and no threshold is indicated.

J. Install fiber-cement underlayment and treat joints according to ANSI A108.11 and manufacturer’s written instructions for type of application indicated. Use latex-Portland cement mortar for bonding material unless otherwise directed in manufacturer’s written instructions.

K. Install waterproofing to comply with ANSI A108.13 and manufacturer’s written instructions to produce waterproof membrane of uniform thickness and bonded securely to substrate.

L. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer’s written instructions to produce membrane of uniform thickness and bonded securely to substrate.

3.04 INTERIOR TILE INSTALLATION SCHEDULE

A. Interior Floor Installations, Concrete Subfloor:

1. Tile Installation F125A: Thin-set mortar on waterproofing crack isolation membrane; TCA F125A.

d) Tile Type: FT-1

e) Thin-Set Mortar: Latex-Portland cement mortar.

f) Grout: Polymer-modified sanded grout.

END OF SECTION 09300

SECTION 09511 - Acoustical Panel Ceilings

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes but is not limited to the following:
   1. Mineral composite painted panel with 15/16 inch (23.81 mm) steel grid.

B. Related Sections: Requirements that relate to this section are included but not limited to the sections below.
   1. Division 1 “General Requirements”.
   2. Division 9 Section “Gypsum Board Assembly” for gypsum board requirements.
   3. Division 21 “Fire Suppression” for work to be coordinated with ceiling.
   4. Division 23 “Heating, Ventilating and Air Conditioning” for work to be coordinated with ceiling.
   5. Division 26 “Electrical” for work to be coordinated with ceiling.

1.3 DEFINITIONS

A. Definitions and Performance Data: Except as otherwise indicated or referenced, technical acoustical terminology used in this section is defined in publications by ASTM, including current edition of "Definition of Terms Relating to Environmental Acoustics", (ASTM C 634).

1.4 SYSTEM DESCRIPTION

A. Design Requirements:
   1. General: Provide work that has been produced, fabricated and installed to withstand project performance requirements for seismic pressure of building structure without failure.
      a. Seismic Requirements: Refer to Division 8 Section “Environmental Performance Requirements and Testing” for seismic zone.

B. Fire Performance Characteristics: Provide acoustical ceiling components that are identical to those tested for the following fire performance characteristics, according to ASTM test method indicated, by UL or other testing and inspecting agency acceptable to authorities having jurisdiction. Identify acoustical ceiling components with appropriate marking of applicable testing and inspecting agency.
   1. Surface Burning Characteristics: ASTM E 84.
      a. Flame Spread: 25 or less.
      b. Smoke Developed: 50 or less.
   2. Fire Resistance Ratings: As indicated by reference to design designation in UL "Fire Resistance Directory" for floor, roof or beam assemblies in which acoustical ceilings function as a fire protective membrane; tested per ASTM E 119. Provide protection materials for lighting fixtures and air ducts to comply with requirements indicated for rated assembly.

1.5 SUBMITTALS

A. General: Submit in compliance with Division 1 Section “Submittal Procedures”.
   1. Submission of submittals indicates that the General Contractor has reviewed and approved the submittals for the following.
      a. Compliance with the requirements of the Contract, Drawings and Project Manual.
      b. Field measurements, field conditions and quantities.
      c. Coordination with adjacent work and trades.
   2. Architect will review submittals for the following.
      a. Compliance with Drawings and Project Manual requirements.
   3. Incomplete submittal may be returned to the General Contractor without review.

B. Product Data:
   1. Submit for action. Describe the properties of items to be used in the Work.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
   1. Ceiling suspension system members.
   2. Method of attaching hangers to building structure.
      a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   4. Minimum Drawing Scale: [1/4 inch = 1 foot (1:48)] [1/8 inch = 1 foot (1:96)] [1:50] [1:100].

E. Samples:
   1. Initial Selection: Submit for action. Furnish manufacturer’s complete color selection showing full range of colors and finish characteristics. Furnish the following:
      a. Acoustical panels.
   2. Verification: Submit for action. Furnish materials to be used with labels indicating colors, finish characteristics, and locations of the Work. Samples will be reviewed for color and appearance only. Furnish the following:
      a. Acoustical Panels: 6 inch (152.4 mm) square samples of each acoustical panel type, pattern and color.
      b. Set of concealed suspension members.

F. Closeout Submittals: Submit the following to the Owner.
   1. Warranty.
   2. Extra material.
   3. Record documents.

1.6 QUALITY ASSURANCE

A. Qualifications:
   1. Contractor: Contractor is responsible for quality control of the Work.
   2. Manufacturer: A firm experienced in successfully producing work similar to that indicated for this Project, with a record of successful in-service performance, and with sufficient production capacity to produce required units without causing delay in the Work.

3. Installer: An installer trained in the use of the materials and equipment to be employed in the Work.

B. Regulatory Requirements: Comply with all applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.

C. Single Source Responsibility: Obtain each type of ceiling system from a single manufacturer.

D. Pre-Installation Meetings: Contractor to conduct meetings at site with installer prior to start of Work. Familiarize installer with conditions at site and related Work.

1.7 DELIVER, STORAGE, AND HANDLING

A. General: Deliver materials in manufacturer's original packaging with label indicating pertinent information identifying the item. Store materials in accordance with manufacturer's instructions in a protected dry location off ground. Do not open packaging nor remove labels until time of installation.

1.8 PROJECT CONDITIONS OR SITE CONDITIONS

A. Environmental Requirements: Proceed with the Work in accordance with manufacturer's requirements and instructions and any agreements or restrictions of the Pre-Construction Conference, including the following.
   1. Do not install interior ceilings until space is enclosed and weatherproof, wet-work in space is completed and nominally dry, work above ceilings is complete, and ambient conditions of temperature and humidity will be continuously maintained at values near those indicated for final occupancy.
   2. Before installing ceiling units, permit them to reach room temperature and a stabilized moisture content.

1.9 SEQUENCING AND SCHEDULING

A. Coordination: Coordinate acoustical ceiling system components with other work, including light fixtures, HVAC equipment, fire-suppression system components (if any), and partition system (if any).

1.10 WARRANTY

A. General: Warranties shall be in addition to, and not a limitation of, other rights the Owner may have under the Contract Documents.

B. Special Warranty: Submit written warranty signed by the manufacturer, installer and contractor, agreeing to repair or replace defective materials or workmanship during the following period beginning at the date of substantial completion.
   1. Warranty Period: Manufacturer's standard but not less than 10 years.

1.11 MAINTENANCE

A. Extra Materials: Furnish for each size, pattern and color installed in the Work. Deliver in manufacturer's original packaging and store at the project site where directed by the Owner. Furnish and deliver the following:
   1. Acoustical Ceiling Units: Quantity of full size units equal to 2.0% of amount installed.
   2. Exposed Suspension System: Quantity of each exposed component equal to 2.0% of amount installed.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Metals:
   1. Steel Sheet: Commercial-quality, cold-rolled, carbon-steel sheet; stretcher leveled, and as follows:
      a. For painted finishes, provide pretreated, pre-finished steel sheet complying with ASTM A 591, Class B coating, chemically treated in mill with phosphate solution and light chromate rinse.
      b. For electroplated finishes, provide uncoated steel sheet complying with ASTM A 1008 with luster or bright finish as required by finisher for applying electroplating.

B. Panels:
   1. General:
      a. Paint surfaces with paints that contain fungicide that inhibits or retards the growth of mold or mildew.
      b. Provide humidity resistant panels that are warranted against sagging or warping.
   2. Mineral Composite Panel: ASTM E 1264. Ceiling Type III (mineral base with painted finish), factory applied vinyl latex paint.
      a. Edge: Square
      b. Manufacturer / Color: Match Architect's sample.
      c. Basis-of-Design:
         1) Subject to compliance with requirements, the design for Mineral Composite Panel is based on the following manufacturer's product.
            a) Armstrong World Industries Inc. "Cermaguard Unperforated 24" x 48 " x 5/8" and 24" x 24" x 5/8".

C. Concealed Support:
   1. Attachment Devices:
   2. Hangers: Type and metal standard with ceiling system manufacturer, sized to comply with structural classification indicated.
      a. Wire Hangers: Size for three (3) times hanger design load indicated in ASTM C 635, Table-1, Direct Hung. Not less than 12 gage.
         1) Galvanized Carbon Steel: ASTM A 641, soft temper, prestretched, Class 1 coating.
         2) Stainless Steel: ASTM A55
      b. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.
      c. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

d. Angle Hangers: Angles with legs not less than 7/8 inch (22.22 mm) wide; formed with 0.04" thick, galvanized steel sheet complying with ASTM A 653, G90 coating designation; with bolted connections and 5/16 inch (7.93 mm) diameter bolts.

3. Hangers and Clips: Type and metal standard with ceiling system manufacturer, sized to comply with structural classification indicated.
   a. Black Iron: MEA approved suspension system in compliance with NYC code.

D. Exposed Metal Suspension Systems, Direct-Hung:
   1. General: Size for five (5) times design load indicated in ASTM C 635, Table 1, Direct Hung.
   2. Steel 15/16 inch (23.8 mm) Wide: Roll-formed double web pretreated cold rolled steel tee structural member. Baked polyester painted cold- rolled steel sheet cap on structural members.
      a. Structural Classification: ASTM C 635. Intermediate-Duty System.
      b. Manufacturer / Color: Match Architect's sample.

E. Miscellaneous:
   1. Edge Moldings and Trim: Metal and finish to match exposed metal suspension system for edges and penetrations of ceiling suspension systems.
   2. Acoustical Sealant: ASTM C 834. Resilient, non-staining, non-shrinking, non-hardening, non-drying, non-sag sealant intended for interior sealing of concealed construction joints.
      a. Manufacturer: Subject to compliance with requirements, provide one of the following:
         1) Pecora Corp. "AC-20 FTR Acoustical and Insulation Sealant"
         2) United States Gypsum Co. "Sheetrock Acoustical Sealant"
   3. Hold Down Clips: Manufacturer standard clips designed to hold down non-fire-resistant-rated panels.
   4. Impact Clips: Manufacturer standard clips designed to absorb impact forces against panels.

F. Metal Finish:
   1. Baked Enamel Finish: AA-C21C42R1x (Chemical Finish: Cleaned with inhibited chemicals; Chemical Finish: chemical conversion coating, acid chromate-fluoride-phosphate pretreatment; Organic Coating: as specified below). Apply baked enamel in compliance with paint manufacturer's specifications for cleaning, conversion coating, and painting.
      a. Baked Enamel Finish: AA-C12C42R1x (cleaned with inhibited chemicals, conversion coated with an acid-chromate-fluoride- phosphate treatment, organic coating specified below):
         1) Organic Coating: Manufacturer's standard thermosetting enamel coating, minimum of 1 heavy coat on face and sides, 1 coat on back.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions: Examine and correct conditions of area to receive the Work prior to installation.

3.2 PREPARATION

A. Field Measurements: Measure each ceiling area and establish layout of acoustical units to balance border widths at opposite edges of each ceiling. Avoid use of less-than-half width units at borders, and comply with reflected ceiling plans wherever possible.

B. Coordinate:
   1. Furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of items having integral anchors embedded in concrete or masonry construction. Coordinate delivery of such items to the project site.
   2. Coordinate layout and installation of acoustical ceiling system components with other work, including light fixtures, HVAC equipment, fire-suppression system components (if any), and partition system (if any).

3.3 INSTALLATION

A. General: Install system in accordance with manufacturer's printed installation instructions, submittals, applicable industry standards, and governing regulatory requirements for the Work.
   1. Fire-resistance rating requirements as indicated.
   2. CISCA standards applicable to work.
   3. Direct-Hung Suspension System: ASTM C 636. Direct-hung suspension system with main runners supported by hangers, attached directly to building structure.
   4. Seismic Restraint: Install materials in accordance with ASTM E 580.

B. Hangers:
   1. Install hangers in accordance with ASTM C 636, with hangers supported only from building structural members. Locate hangers not less than 6 inch (152.4 mm) from each end and spaced 48 inch (1,219.2 mm) along each carrying channel or direct-hung runner, unless otherwise indicated, leveling to tolerance of 1/8 inch (3.175 mm) in 12 feet (3.657 m).
      a. Secure wire hangers by looping and wire-tying, either directly to structures or to inserts, eye-screws, or other devices which are secure and appropriate for substrate, and which will not deteriorate or fail with age or elevated temperatures.
      b. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum which are not part of supporting structural or ceiling suspension system. Splay hangers only where required to miss obstructions and offset resulting horizontal force by bracing, countersplaying or other equally effective means.
   2. Provide separate supporting devices for air distribution devices, lighting fixtures and other item not part of ceiling system.

C. Acoustical Panels:
   1. Arrange acoustical units and orient directionally-patterned units (if any) in manner shown by reflected ceiling plans.
      a. Install panels with pattern running in one direction.
   2. Install acoustical panels in coordination with suspension system, ceiling fixtures and penetrations. Conceal edges of panels with support of suspension members. Scribe and cut panels to fit accurately at borders and at penetrations.
   3. Hold Down Clips:
      a. General: Space as recommended by panel manufacturer, unless otherwise indicated or required.

b. Provide in the following locations.
   1) Areas as indicated.

3.4 FIELD QUALITY CONTROL

A. Site Test: Testing laboratory, engaged at the Owner's expense, will perform the following activities at the Owner's discretion.
   1. Extent and Testing Frequency: Testing will take place in successive stages as described below. Proceed with installation of acoustical panel ceilings only after test results for previously installed hangers comply with requirements.
      a. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
      b. Within each test area, testing will select one of every 10 powder-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbs (90.8 kg) of tension; it will also select one of every two postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbs (199.76 kg) of tension.
      c. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 consecutively pass and then will resume initial testing frequency.
   2. Testing agency will report test results promptly and in writing to Contractor and Architect.
   3. Remove and replace those fasteners and anchors that test results indicate do not comply with specified requirements.
   4. Additional Testing: Where fasteners and anchors are removed and replaced, additional testing will be performed to determine compliance with specified requirements.

3.5 CLEANING

A. At the end of each work day, remove unused materials, debris and containers from the site.

B. Clean exposed surfaces of acoustical ceilings, including trim, edge moldings, and suspension members; comply with manufacturer's instructions for cleaning and touch-up of minor finish damage. Remove and replace work which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 5113

SECTION 09900 - PAINTING AND COATING

PART 1. GENERAL

1.01 SCOPE OF WORK

A. This specification applies to the field painting of structural and miscellaneous steel, walls, doors and frames. Painting shall include surface preparation, protection of surfaces not being painted, application of paint, clean-up and all miscellaneous materials and operations required for a complete application. The extent of the work shall be as shown on drawings, and defined in the Scope of Work.

B. Surface preparation, application and paint materials shall be as specified in the Paint System Specification sheets. The Paint System Specification sheets are a part of this specification.

C. The term "paint" as used herein means all generic types of paints and coatings including single-component and multiple component systems

1.02 RELATED SECTIONS

A. Shop applied prime painting associated with shop fabricated items such as structural and miscellaneous steel, metal doors, mechanical and electrical equipment, and other like work where provision of prime paint is the normal and established practice, is not included herein.

1.03 SECTION INCLUDES

A. Architectural painting

B. High performance coating

1.04 REFERENCED SPECIFICATIONS CODES AND STANDARDS

A. Without limiting the generality of other requirements of these specifications, all work hereunder shall conform to the applicable requirements of the referenced portions of the following documents, to the extent that the requirements therein are not in conflict with the provisions of this Section. All references and standards listed shall be the latest revisions. Joint and individual documents are referenced.

1. SSPC – The Society for Protective Coatings
   40 24th Street, 6th Floor
   Pittsburgh, PA 15222-4643
   (412) 281-2331

2. NACE – National Association of Corrosion Engineers
   P.O. Box 218340
   Houston, TX 77218-8340
   (281) 492-0535

3. ICRI – International Concrete Repair Institute
   3166 S. River Rd., Suite 132
   Des Plaines, Il 60018
   (847) 827-0830

4. ASTM – American Society for Testing and Materials
   100 Barr Harbor Drive
   West Conshohocken, PA 19428-2959
   (610) 832-9585

B. Provide three copies of a schedule detailing each substrate in the same order as the schedules used in PART 3 of this section. Include the following:

1. The specific products to be used for each coat

2. Documentation that the manufacturer has reviewed and approved each painting system

3. Data pages for all products listed

4. On one set of data pages, highlight the following:

5. Type of resin

6. Dry Film Thickness

7. Volume Solids

8. Units of Sheen

9. Other performance or descriptive data required by PART 2 of this section

10. If this information is not on the data page provide the information in a letter of certification from the manufacturer. Attach the letter to the appropriate data page.

C. Submit 3 drawdowns of each product and color combination. Drawdowns shall be applied using a 4 mil WFT drawdown bar on plain white coated 12" square draw down cards size.

1. Label each card with the following:

   a) Job name

   b) Date

   c) Product name

   d) Product number

   e) Color number as stated in the color schedule

f) Name, address, and phone number of the supplying facility.

1.05 MAINTENANCE

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.06 JOB CONDITIONS

A. All paint materials shall conform with volatile organic compound (VOC) rating of 3.5 or less and/or conforming to state and local regulations and requirements.

B. Environmental Conditions:

1. Apply paint when the surface and surrounding environmental conditions are within the limitations specified by the paint manufacturer.

2. Interior painting shall not be performed in areas where dust is in the air or may be generated before paint can cure to tack-free state. Exterior painting shall not be performed during dusty and windy conditions.

C. Provide ventilation and personal protective equipment in accordance with applicable codes. Provide ventilation to permit the removal of solvent and water vapors during the drying or curing period.

D. Protection:

1. Store all paint, solvents, thinners and associated materials in metal containers with tight-fitting covers.

2. Store used rags in covered metal containers. Used rags shall be removed from the premises at the end of each work day.

3. Do not allow smoking in storage spaces and while using or mixing paint and other combustible materials.

4. Provide fire protection equipment at all locations where painting is in progress, in accordance with applicable codes.

5. Provide drop cloths to protect surfaces adjacent to painting work, from paint droppings. All drop cloths shall be fire retardant and free of dust, lint and excessive paint droppings.

E. Coordinate the painting work with the work of other trades in order to prevent re-cleaning and touching-up of previously applied paint.

PART 2. PRODUCTS

2.01 PAINT MANUFACTURERS

A. In addition to the acceptable products of the manufacturers listed on the Paint System Specifications in Part 3, the following manufacturers comparable products shall be acceptable, subject to the approval of the Engineer.

1. Glidden Professional

2. Devoe High Performance Industrial Coatings

3. Benjamin Moore

4. Carboline

B. Specified products unless otherwise indicated are manufactured by The Sherwin-Williams Company and establish the required level of quality. Substitute products shall meet all descriptive and performance requirements.

PART 3. EXECUTION

3.01 EXAMINATION

A. Do not begin application of coatings until substrates have been properly prepared. Notify Architect of unsatisfactory conditions before proceeding

B. If substrate preparation is the responsibility of another installer, notify Design Professional of unsatisfactory preparation before proceeding.

C. Proceed with work only after conditions have been corrected, and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions.

D. On previously coated surfaces, primer may be omitted except for spot priming as needed.

3.02 SURFACE PREPARATION

A. The surface shall be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.

B. Remove mildew before painting by washing with a solution of 1 part liquid household bleach and 3 parts of warm water. Apply the solution and scrub the mildewed area. Allow the solution to remain on the surface for 10 minutes. Rinse thoroughly with clean water and allow the surface to dry 48 hours before painting. Wear protective glasses or goggles, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.

C. No exterior painting shall be done immediately after a rain, during foggy weather, when rain is predicted, or when the temperature is below 50°F unless the specified product is designed for the marginal conditions.

D. Methods

1. Aluminum

   a) Remove all oil, grease, dirt, oxide and other foreign material by cleaning per SSPC-SP1, Solvent Cleaning.

2. Block (Cinder and Concrete)

   a) Remove all loose mortar and foreign material. Surface shall be free of laitance, concrete dust, dirt, form release agents, moisture curing membranes, loose cement, and hardeners. Concrete and mortar shall be cured at least 30 days at 75°F, unless the manufactures products are designed for application prior to the 30-day period. The pH of the surface shall be between 6 and 9,unless the products to be used are designed to be used in high pH environments such as Loxon. On tilt-up and poured-in-place concrete, commercial detergents and abrasive blasting may be necessary to prepare the surface. Fill bug holes, air pockets, and other voids with a cement patching compound.

3. Concrete, SSPC-SP13 or NACE 6

   a) An acceptable prepared concrete surface shall be free of contaminants, laitance, loosely adhering concrete, and dust, and shall provide a sound, uniform substrate suitable for the application of protective coating or lining systems. Surface preparation of floors shall be further modified by the ICRI standard cited in coating schedule.

4. Cement Composition Siding/Panels

   a) Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry.

5. Copper and Stainless Steel

   a) Solvent cleaning per SSPC-SP1 and SSPC-SP 2/3 Hand Tool/Power Tool Cleaning.

6. Drywall—Interior

   a) Shall be clean and dry. All nail heads shall be set and spackled. Joints shall be taped and covered with a joint compound. Spackled nail heads and tape joints shall be sanded smooth and all dust removed prior to painting.

7. Galvanized Metal

   a) Clean per SSPC-SP1 using detergent and water or a degreasing cleaner to remove greases and oils. Apply a test area, priming as required. Allow the coating to dry at least one week before testing. If adhesion is unsatisfactory, Brush Blast per SSPC-SP7 is necessary to remove these treatments.

8. Interior Ferrous Metal on buildings, if existing coating is sound

   a) Solvent cleaning per SSPC-SP1 and SSPC-SP 2/3 Hand Tool/Power Tool Cleaning, unless otherwise directed.

9. Exterior Ferrous Metal Steel Structures

   a) Solvent cleaning per SSPC-1 and Commercial Blast Cleaning per SSPC-SP6 or NACE 3, unless otherwise directed.

10. Wood

    a) Ensure that wood is clean and dry. Prime and stain as soon as possible. Knots and pitch streaks shall be scraped, sanded, and spot primed before a full priming coat is applied. Patch all nail holes and imperfections with a wood filler or putty and sand smooth.

3.03 EXTERIOR PAINTING SCHEDULE

(Note: Verify the specifications of all paint systems with owner prior to application).

A. Ferrous Metal - Acrylic System:

1. 1st Coat: S-W ProIndustrial Pro-Cryl Universal Primer @ 2.0 – 4.0 mils DFT (On previously shop primed surfaces, primer may be omitted except for spot painting)

2. 2nd Coat: S-W Sher-Cryl HPA Gloss @ 2.5 – 4.0 mils DFT

B. Ferrous Metal – Medium Duty Epoxy System:

1. 1st Coat: S-W Macropoxy 646 FF @ 5.0 – 10.0 mils DFT

2. 2nd Coat: S-W Acrolon Ultra Gloss @ 2.0 – 3.0 mils DFT

C. Zinc-coated Metal (where scheduled to receive paint only) - Medium Duty Epoxy System:

1. 1st Coat: S-W Macropoxy 646 @ 2.0 – 4.0 mils DFT

2. 2nd Coat: S-W Acrolon Ultra Gloss @ 2.0 – 3.0 mils DFT
   Note: Top handrails, bollards and ladders are to be painted in safety yellow where indicated on drawings. (color SW4084).

D. Floor Markings:

1. 1st Coat: S-W Pro-Park Waterborne Traffic Marking Paint @ 8.0 – 10.0 mils DFT (approximately 330 linear feet per gallon)

3.04 INTERIOR PAINTING SCHEDULE

(Note: Verify the specifications of all paint systems with owner's representative prior to application).

A. Gypsum Drywall Substrates – Vinyl Acrylic System:

1. 1st Coat: S-W ProMar 200 Zero VOC Interior Latex Primer B28W2600 @ 1.5 mils DFT

2. 2nd Coat: S-W ProMar 200 Zero VOC Interior Latex Eg-Shell B20_2600 series @ 1.7 mils DFT

3. 3rd Coat: S-W ProMar 200 Zero VOC Interior Latex Eg-Shell B20_2600 series @ 1.7 mils DFT

B. Gypsum Drywall Substrates (ceiling and soffits) – Vinyl Acrylic System:

1. 1st Coat: S-W ProMar 200 Zero VOC Interior Latex Primer B28W2600 @ 1.5 mils DFT

2. 2nd Coat: S-W ProMar 200 Zero VOC Interior Latex Flat B30_2600 series @ 1.6 mils DFT

3. 3rd Coat: S-W ProMar 200 Zero VOC Interior Latex Flat B30_2600 series @ 1.6 mils DFT

C. Gypsum Drywall Substrates (walls and ceilings) – Medium Duty Epoxy System:

1. 1st Coat: S-W ProMar 200 Zero VOC Interior Latex Primer B28W2600 @ 1.5 mils DFT

2. 2nd Coat: S-W ProIndustrial Zero VOC Waterborne Catalyzed Epoxy Gloss B73_300 series @ 2.0 – 4.0 mils DFT

D. Concrete Masonry Units Substrates – Acrylic System:

1. 1st Coat: S-W Heavy Duty Block Filler B42W46 @ 50 – 88 sq. ft. per gallon

2. 2nd Coat: S-W ProMar 200 Zero VOC Interior Latex Semi-gloss B31_2650 series @ 1.6 mils DFT

3. 3rd Coat: S-W ProMar 200 Zero VOC Interior Latex Semi-gloss B31_2650 series @ 1.6 mils DFT

E. Concrete Masonry Units Substrates – Medium Duty Epoxy System:

1. 1st Coat: S-W Heavy Duty Block Filler B42W46 @ 50 – 88 sq. ft. per gallon

2. 2nd Coat: S-W ProIndustrial Zero VOC Waterborne Catalyzed Epoxy Gloss B73_300 series @ 2.0 – 4.0 mils DFT.

F. Concrete Masonry Units and Concrete Substrates – Heavy Duty Epoxy System:

1. 1st Coat: S-W Kem Cati-Coat HS Epoxy @ 60 – 115 sq. ft. per gallon, back roll to fill all bug holes and create a uniform pinhole-free surface.

2. 2nd Coat: S-W Macropoxy 646 @ 5.0 – 10.0 mils DFT

3. 3rd Coat: S-W ProIndustrial High Performance Epoxy B67_200 series @ 4.0 – 8.0 mils DFT

G. Ferrous Metal Substrates (Interior Hollow Metal Frames and doors) – Acrylic System:

1. 1st Coat: S-W ProIndustrial Pro-Cryl Universal Primer @ 2.0 – 4.0 mils DFT (On previously shop primed surfaces, primer may be omitted except for spot painting)

2. 2nd Coat: S-W ProIndustrial Zero VOC Acrylic Semi-gloss B66_650 series @ 2.5 – 4.0 mils DFT

H. Ferrous Metal Substrate (Exposed Interior Structural Steel) – Medium Duty and Heavy Duty Epoxy System:

1. 1st Coat: S-W Macropoxy 646 FF @ 5.0 – 10.0 mils DFT

2. 2nd Coat: S-W ProIndustrial High Performance Epoxy B67_200 series @ 4.0 – 8.0 mils DFT

I. Zinc-coated metal (Where scheduled to receive paint.) – Heavy Duty Epoxy System:

1. 1st Coat: S-W Macropoxy 646 FF @ 2.0 – 4.0 mils DFT

2. 2nd Coat: S-W ProIndustrial High Performance Epoxy B67_200 series @ 4.0 – 8.0 mils DFT

Note: Top handrails and ladders are to be painted in safety yellow where indicated on drawings. (color SW4084).

3.05 CLEANING

A. Remove all unused materials, partially used materials, waste materials, and other supplies except for maintenance materials as required by the specifications.

END OF SECTION 09900

SECTION 10200 - LOUVERS, VENTS AND SCREENS

PART 1. GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Fixed, extruded-aluminum louvers.

B. Related Sections include the following:

1. Division 7 Section “Joint Sealants” for sealants installed in perimeter joints between louver frames and adjoining construction.

2. Division 15 Sections for louvers and vents that are part of mechanical equipment.

1.02 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide louvers, vents and screens capable of withstanding the effects of gravity loads and wind loads based on a uniform pressure of 30 lbf/sq. ft. acting inward or outward, without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors.

B. Thermal Movements: Provide louvers, vents and screens that allow for thermal movements resulting from a temperature change (range) of 120° F, ambient; 180° F, material surfaces, by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

C. Air-Performance, Water-Penetration, and Wind-Driven Rain Ratings: As demonstrated by testing manufacturer's stock units according to AMCA 500-L.

1.03 QUALITY ASSURANCE

A. Louvers licensed to bear AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 511 and comply with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to air performance and water penetration ratings.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other Work. Show blade profiles, angles, and spacing.

1. Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings.

2. Include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Samples for Verification: For each type of metal finish required.

E. Product test reports.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a dry area indoors, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Protect materials and finishes during handling and installation to prevent damage.

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airolite Company

2. Construction Specialties, Inc.

3. Greenheck.

4. Ruskin Company; Tomkins PLC.

C. Basis-of-Design Product: The design for each louver is based on product listed. Subject to compliance with requirements, provide the named product or a comparable product by one of the other manufacturers specified.

2.02 MATERIALS

A. Aluminum Extrusions: ASTM B 221 alloy 6063-T6 or T-52.

B. Aluminum Sheet: ASTM B 209 alloy 3003 or 5005.

C. Fasteners: Of same basic metal and alloy as fastened metal or 300 Series stainless steel.

2.03 FABRICATION, GENERAL

A. Fabricate frames to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

B. Join frame members to each other and to louver blades with fillet welds concealed from view.

C. Join frame members to each other and to louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer, concealed from view.

2.04 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Double Drainable-Blade Louver

1. Basis-of-Design Product: Ruskin ELF6425DD Continuous Drainable Stationary Louver or a comparable product of one of the above listed manufacturers.

2. Frame:

a) Material: Extruded aluminum, Alloy 6063-T6.

b) Wall Thickness: 0.081”, nominal.

c) Depth: 6”.

d) Downspouts and caulking surfaces.

3. Extended Sills: Extruded aluminum, Alloy 6063-T6. Minimal nominal thickness 0.060 inch.

4. Blades:

a) Style: double drainable with continuous leading edge.

b) Material: Extruded aluminum, Alloy 6063-T6.

c) Wall Thickness: 0.081”, nominal

d) Angle: 42.5°.

e) Centers: 5”, nominal

5. Gutters: Dual drain gutters in each blade.

6. Downspouts: Downspouts in concealed mullions to drain water from louver for minimum water cascade from blade to blade.

7. Concealed Mullions recessed 2” from exterior and placed at 120” to drain blade butters without interruption of the leading edge of the blades.

8. Vertical Supports: Hidden vertical supports to allow continuous line appearance up to 240”.

9. Assembly: Factory assemble louver components.

10. Performance Requirements:

    a) Net Free Area: Not less than 49 percent.

    b) Point of Beginning Water Penetration at 0.01oz./sq. ft.: 852fpm (free area velocity)

    c) Air Performance: Not more than 0.10-inch wg static pressure drop at 800-fpm free-area velocity.

11. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.05 LOUVER SCREENS

A. General: Provide screen at each exterior louver.

1. Screen Location for Fixed Louvers: Interior face.

2. Screening Type: Bug screening.

B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6” from each corner and at 12” o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.

2. Finish: Same finish as louver frames to which louver screens are attached.

3. Type: Rewirable frames with a driven spline or insert for permanently securing screen mesh.

2.06 BLANK-OFF PANELS

A. Insulated, Blank-off Panels: Laminated metal-faced panels consisting of insulating core surfaced on back and front with metal sheets.

1. Thickness: 2”.

2. Metal Facing Sheets: Aluminum sheet, not less than 0.032” nominal thickness.

3. Insulating Core: Foamed-plastic rigid insulation board.

4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer’s standard extruded-aluminum-channel frames, not less than 0.080-inch nominal thickness, with corners mitered and with same finish as panels.

5. Seal perimeter joints between panel faces and louver frames with 1/8” by 1” PVC compression gaskets.

6. Panel Finish: Same finish applied to louvers.

7. Attach blank-off panels to back of louver frames with stainless-steel, sheet metal screws.

2.07 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.

B. High-Performance Organic-Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Fluoropolymer Three-Coat Coating System: Manufacturer's standard three-coat, thermocured system consisting of specially formulated inhibitive primer, fluoropolymer color, and clear fluoropolymer topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2605.

d) Color and Gloss:

1) Horizontal Louvers: Custom color to match metal wall panels.

PART 3. EXECUTION

3.01 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.03 INSTALLATION

A. Locate and place louvers, vents and screens level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Repair damaged finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

E. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

3.04 ADJUSTING AND CLEANING

A. Clean exposed surfaces of louvers, vents and screens that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers, vents and screens damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by A/E, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 10200

SECTION 10523 - FIRE EXTINGUISHERS

PART 1. GENERAL

1.01 SUMMARY

A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

1.02 ACTION SUBMITTALS

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

1.03 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.

C. Coordinate type and capacity of fire extinguishers with fire protection cabinets to ensure fit and function.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a) Failure of hydrostatic test according to NFPA 10.

b) Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Substantial Completion.

PART 2. PRODUCTS

2.01 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each mounting bracket indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a) Amerex Corporation.

b) Ansul Incorporated; Tyco International Ltd.

2. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B and bar coding for documenting fire extinguisher location, inspections, maintenance, and recharging.

B. Multipurpose Dry-Chemical Type: UL-rated 4-A:60-B:C, 10-lb nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled container.

C. Clean-Agent Type in Steel Container: UL-rated, 1-A:10-B:C, 10-lb nominal capacity, with HFC blend agent and inert material in enameled-steel container; with pressure-indicating gage.

2.02 MOUNTING BRACKETS

A. Mounting Brackets: Manufacturer's standard galvanized steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or red baked-enamel finish.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a) Amerex Corporation.

b) Ansul Incorporated; Tyco International Ltd.

c) Badger Fire Protection; a Kidde company.

d) Buckeye Fire Equipment Company.

e) Fire End & Croker Corporation.

f) J. L. Industries, Inc.; a division of Activar Construction Products Group.

g) Larsen's Manufacturing Company.

h) Potter Roemer LLC.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Architect.

1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.

a) Orientation: Vertical.

PART 3. EXECUTION

3.01 INSTALLATION

A. Examine fire extinguishers for proper charging and tagging.

1. Remove and replace damaged, defective, or undercharged fire extinguishers.

B. Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

1. Mounting Brackets: 54” above finished floor to top of fire extinguisher.

C. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

END OF SECTION 10523

SECTION 10800 – TOILET ACCESSORIES

PART 1. GENERAL

1.01 SUMMARY

A. Section Includes:

1. Washroom accessories.
2. Under lavatory guards.
3. Custodial accessories.

1.02 ACTION SUBMITTALS

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

B. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.

1. Identify locations using room designations indicated.
2. Identify products using designations indicated.

1.03 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.05 QUALITY ASSURANCE

A. Source Limitations: For products listed together in the same articles in Part, provide products of same manufacturer unless otherwise approved by the architect.

1.06 WARRANTY

A. Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

1.07 COORDINATION

A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

PART 2. **PRODUCTS**

2.01 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 0.0312” minimum nominal thickness, unless otherwise indicated.

B. Brass: ASTM B 19 flat products; ASTM B 16 rods, shapes, forgings, and flat products with finished edges; or ASTM B 30, castings.

C. Steel Sheet: ASTM A 1008 Designation CS (cold rolled, commercial steel), 0.0359” minimum nominal thickness.

D. Galvanized Steel Sheet: ASTM A 653, with G60 hot-dip zinc coating.

E. Galvanized Steel Mounting Devices: ASTM A 153, hot-dip galvanized after fabrication.

F. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

G. Chrome Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).

2.02 WASHROOM ACCESSORIES

A. Basis-of-Design Product: The design for accessories is based on products indicated. Subject to compliance with requirements, provide the named product or a comparable product by one of the following:

1. A & J Washroom Accessories, Inc.

2. American Specialties, Inc.

3. Bobrick Washroom Equipment, Inc.

4. Bradley Corporation.

B. Toilet Tissue Dispenser

1. Basis-of-Design Product: American Specialties, Inc. 20030 Surface Mounted Twin Hide-a-roll Toilet Tissue Dispenser.

2. Series: Roval

3. Lock: Tumbler

4. Mounting: Surface Mounted.

C. Grab Bar:

1. Basis-of-Design Product: A.S.I. 3800 P Series.

2. Mounting: Flanges with concealed fasteners.

3. Material: Stainless steel, 0.05” thick.

a) Finish: Smooth, No. 4, satin finish on ends and slip-resistant texture in grip area.

4. Outside Diameter: 1-1/2”.

5. Configuration and Length: Straight, various lengths as shown on plans.

D. Sanitary Napkin Disposal (Feminine Hygiene Disposals):

1. Basis-of-Design Product: A.S.I. 20852 Series.

2. Mounting: Surface.

3. Series: Roval.

4. Material: Stainless steel.

5. Size: 7-1/4”x10”x3-1/2”

E. Paper Towel Dispenser:

1. Basis-of-Design Product: A.S.I. 20210 Series.

2. Description: Surface mounted 400 C-fold paper towel dispenser.

3. Mounting: Surface.

4. Material: 22 gauge Type 304 stainless steel.

5. Lock: Tumbler.

6. Size: Dispenses 400 C-fold or 525 multi-fold paper towels.

F. Above Sink Mirror Unit:

1. Basis-of-Design Product: A.S.I. #20655, with theft resistant back plate and shelf.

2. Series: Roval.

3. Mounting: Surface with tamperproof mounting mechanism

4. Material: 18 gauge type 304 stainless.

5. Glass: 1/4” tempered glass.

6. Options: with shelf

7. Size: Size as indicated on drawings

G. Soap Dispenser:

1. Basis-of-Design Product: A.S.I. #20364

2. Description: Surface mounted automatic foam soap dispenser.

3. Mounting: Surface.

4. Series: Roval.

5. Material: 22 gauge type 304 stainless

6. Capacity: 33.8 oz.

7. Operation: Sensor.

8. Options: Provide starter kit with soap and batteries.

H. Shelf and Mop-hook (Provide in Janitor’s Closet):

1. Basis-of-Design Product: A.S.I. 1315-3 Series.

2. Mounting: Surface.

3. Material: Stainless steel.

4. Description: Utility shelf with three mop holders, 2 rag hooks, and rod, 30” long.

I. Not Used.

J. Under lavatory Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a) Plumberex Specialty Products, Inc.

b) TCI Products

c) Truebro Inc.

2. Description: Insulating pipe covering for supply and drain piping assemblies that prevent direct contact with and burns from piping, and allow service access without removing coverings.

3. Material and Finish: Antimicrobial, molded-plastic, white

K. Freestanding Refuse Container:

a) Basis-of-Design Product: A.S.I. 0812 Series .

b) Mounting: Freestanding.

c) Material: Stainless steel.

d) Description: Stainless Steel Free Standing Waste Receptacle

e) Specification: 19 gal. Capacity with stainless steel swing top.

2.03 Fabrication

A. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3. **EXECUTION**

3.01 Installation

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbs when tested according to ASTM F 446.

END OF SECTION 10800

SECTION 15010 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 15 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in the specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern the furnishing, installing, testing and placing into satisfactory operation the Mechanical Systems.

B. Each Subcontractor shall provide all new materials indicated on the drawings and/or in these specifications, and all items required to make his portion of the Mechanical Work a finished and working system.

1.3 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL SUBCONTRACTORS

A. Definitions:

1. "Mechanical Subcontractors" refers to the following:

a. Plumbing Subcontractor.
b. Heating Subcontractor.
c. Air Conditioning and Ventilating Subcontractor.
d. Temperature Control Subcontractor.
e. Fire Protection Subcontractor.
f. Testing, Adjusting, and Balancing Subcontractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.

3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.

5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either

modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Subcontractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Subcontractor.

2. Where the drawings require the Electrical Subcontractor to wire between equipment furnished by the Mechanical Subcontractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Subcontractor shall provide complete wiring diagrams and supervision to the Electrical Subcontractor and designate the terminal numbers for correct wiring.

3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Subcontractor unless noted otherwise.

C. Mechanical Subcontractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Subcontractor, for example:

a. Packaged Rooftop Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Subcontractor is a Subcontractor to the Mechanical Subcontractor.

3. Temperature Control Subcontractor's Responsibility:

a. Wiring of all devices needed to make the Temperature Control System functional.

b. Verifying any control wiring on the electrical drawings as being by the Electrical Subcontractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.

c. Coordinating equipment locations (such as P.E.'s, E.P.'s, relays, transformers, etc.) with the Electrical Subcontractor, where wiring of the equipment is by the Electrical Subcontractor.

4. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

D. Electrical Subcontractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Subcontractor on the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Subcontractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Provides motor control and temperature control wiring, where so noted on the drawings.

4. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 16.

5. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by Fermilab are acceptable.

2. All Subcontractors and subcontractors shall employ only workers skilled in their trades.

B. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of Fermilab Codes, Laws, Ordinances and other regulations having jurisdiction.

2. Conform to all State Codes.

3. Conform to Federal Act S.3874 requiring the reduction of lead in drinking water.

4. If there is a discrepancy between the codes and regulations and these specifications, Fermilab shall determine the method or equipment used.

5. If the Subcontractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform Fermilab in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

6. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Subcontractor without cost to Fermilab.

7. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

C. Examination of Drawings:

1. The drawings for the mechanical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Subcontractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.

3. Scaling of the drawings is not sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Subcontractor at no additional cost to Fermilab.

5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either on the drawings or in the specifications, it shall be included in this contract.

7. Determination of quantities of material and equipment required shall be made by the Subcontractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.

8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.

   b. Any item listed as installed shall also be furnished, unless otherwise noted.

D. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

E. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Subcontractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. If the information requested includes floor plans prepared by others, the Subcontractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

5. The use of these CAD documents by the Subcontractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

1.5 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Subcontractor and/or Fermilab. If the Mechanical Subcontractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Subcontractor is responsible for moving equipment into the building and/or site. Subcontractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Subcontractor shall coordinate his/her work with other trades.

1.6 PROJECT COMMISSIONING

A. The Subcontractor shall work with the Commissioning Agent (CxA) as described in Section 15995 and provide all services necessary.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Subcontractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found at the following website:

2. The Subcontractor shall do all excavating, filling, backfilling and compacting associated with his work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.

2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by Fermilab, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Subcontractor's expense.

3. Trim bottom and sides of excavations to grades required for foundations.

4. Protect excavations against frost and freezing.

5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.

6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.

7. Where satisfactory bearing soil for foundations is not found at the indicated levels, Fermilab or their representative shall be notified immediately, and no further work shall be done until further instructions are given by Fermilab or their representative.

C. Dewatering:

1. Subcontractor shall furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.

2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by Fermilab.

E. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.

2. Provide all necessary sand for backfilling.

3. Dispose of the excess excavated earth as directed.

4. Backfill materials shall be suitable for required compaction, clean and free of perishable materials and stones greater than 4 inches in diameter. Water shall not be permitted to rise in unbackfilled trenches. No material shall be used for backfilling that contains frozen earth, debris or earth with a high void content.

5. Backfill all trenches and excavations immediately after installing pipes, or removal of forms, unless other protection is provided.

6. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

7. Lay all piping on a compacted bed of sand at least 3 inches deep. Backfill around pipes with sand, 6 inch layers, and compact each layer.

8. Use sand for backfill up to grade for all piping under slabs or paved areas. All other piping shall have sand backfill to 6 inches above the top of the pipe.

9. Place all backfill above the sand in uniform layers not exceeding 6 inches deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.

10. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T-99 or ASTM D-698 test.

3.2 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Before final payment is authorized, this Subcontractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including marked-up or reproducible drawings and specifications.

3. A report documenting the instructions given to Fermilab's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Subcontractor and shall be signed by Fermilab's representatives.

4. Start-up reports on all equipment requiring a factory installation inspection or start-up.

5. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed; receipt by Fermilab required prior to final payment approval.

3.3 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Fermilab’s review and approval. The electronic copy shall be corrected as required to address Fermilab’s comments. Once corrected, electronic copies and paper copies shall be distributed as directed by Fermilab.

2. Approved O&M manuals shall be completed and in Fermilab's possession prior to Fermilab's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by Fermilab.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div15.subcontractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div15.subcontractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide Fermilab with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Paper Copy Submittal Procedures:

1. Once the electronic version of the manuals has been approved by Fermilab, 2 paper copies of the O&M manual shall be provided to Fermilab. The content of the paper copies shall be identical to the corrected electronic copy.

2. Binder Requirements: The Subcontractor shall submit three sets of O&M manuals in heavy duty, locking three ring binders. Incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. “Peel and stick” labels are **not** acceptable. Sheet lifters shall be supplied at the front of each notebook. The three-ring binders shall be 1/2" thicker than initial material to allow for future inserts. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other form of binding is acceptable.

3. Binder Labels: Label the front and spine of each binder with “Operation and Maintenance Instructions”, title of project, and subject matter.

4. Index Tabs: Divide information by specification section, major equipment, or systems using index tabs. All tab titling shall be clearly printed under reinforced plastic tabs. All equipment shall be labeled to match the identification in the construction documents.

D. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Subcontractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Refer to Section 15952 for additional requirements for Temperature Control submittals.

5. Copy of final approved test and balance reports.

6. Copies of all factory inspections and/or equipment startup reports.

7. Copies of warranties.

8. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

9. Dimensional drawings of equipment.

10. Capacities and utility consumption of equipment.

11. Detailed parts lists with lists of suppliers.

12. Operating procedures for each system.

13. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

14. Repair procedures for major components.

15. List of lubricants in all equipment and recommended frequency of lubrication.

16. Instruction books, cards, and manuals furnished with the equipment.

3.4 INSTRUCTING FERMILAB'S REPRESENTATIVES

A. Adequately instruct Fermilab's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to Fermilab's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Fermilab has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Explanation of all air handling systems.
2. Temperature control system operation including calibration, adjustment and proper operating conditions of all sensors.
3. Maintenance of equipment.
4. Stairwell pressurization systems.
5. Start-up procedures for all major equipment.
6. Explanation of seasonal system changes.
7. Description of emergency system operation.

E. Fermilab shall be notified of the time and place instructions will be given to Fermilab's representatives so he or his representative can attend if desired.

F. Minimum hours of instruction for each item shall be:

1. Sprinkler System(s) - 2 hours.
2. Air Handling System(s) - 2 hours.
3. Exhaust System(s) - 2 hours.
4. Temperature Controls - As defined in Specification Section 15952.

G. The Subcontractor shall prepare a detailed, written training agenda and submit it to Fermilab a minimum of two weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Subcontractor.

H. Operating Instructions:

1. Subcontractor is responsible for all instructions to Fermilab's representatives for the mechanical and control systems.

2. If the Subcontractor does not have staff that can adequately provide the required instructions he shall include in his bid an adequate amount to reimburse Fermilab for Fermilab to perform these services.

3.5 SYSTEM COMMISSIONING

A. The mechanical systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Subcontractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. Operate all HVAC systems continuously for at least one week prior to occupancy to bring construction materials to suitable moisture levels. Areas with mechanical cooling shall be maintained below 60% RH.

C. Subcontractor shall adjust the mechanical systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

D. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

E. The Subcontractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If Fermilab is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Subcontractor shall reimburse Fermilab on a time and materials basis for services rendered at Fermilab's standard hourly rates in effect when the services are requested. The Subcontractor shall pay Fermilab for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.6 RECORD DOCUMENTS

A. The following paragraph supplements Division 1 requirements:

Subcontractor shall maintain at the job site a separate and complete set of mechanical drawings and specifications on which he shall clearly and permanently mark in complete detail all changes made to the mechanical systems.

B. Mark drawings to indicate revisions to piping and ductwork, size and location, both exterior and interior; including locations of coils, dampers, other control devices, filters, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (e.g., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

C. Refer to Specification Section 15952 for additional requirements for Temperature Control documents.

D. Before completion of the project, a set of reproducible mechanical drawings will be given to the Subcontractor for transfer of all as-built conditions from the paper set maintained at the job site. All marks on reproducibles shall be clear and permanent.

E. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

F. Record changes daily and keep the marked drawings available for Fermilab's examination at any normal work time.

G. Upon completing the job, and before final payment is made, give the marked-up drawings to Fermilab.

3.7 PAINTING

A. Subcontractor shall paint all equipment that is marred or damaged prior to Fermilab's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available.

B. Equipment cabinets, casings, covers, metal jackets, etc., in equipment rooms or concealed spaces, shall be furnished in standard or prime finish, free from scratches, abrasions, chips, etc.

C. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chips, etc. If color option is specified or is standard to the unit, this Subcontractor shall, before ordering, verify with Fermilab his color preference and furnish this color.

D. Paint all equipment in unfinished areas furnished by this Subcontractor. Equipment furnished with a factory coat of paint and enamel need not be painted, provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

E. Paint all outdoor uninsulated steel piping the color selected by Fermilab or Fermilab.

F. After surfaces have been thoroughly cleaned and are free of oil, dirt, and other foreign matter; paint all pipes and equipment with the following:

1. Bare Metal Surfaces - Apply one coat of primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.

2. Insulated Surfaces - Paint insulation jackets with two coats of semi-gloss acrylic latex paint.

3. Color of paint shall be selected by Fermilab.

3.8 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to Fermilab's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all drain pans and areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.9 SPECIAL REQUIREMENTS

A. Subcontractor shall coordinate the installation of all equipment, valves, dampers, operators, etc., with other trades to maintain clear access area for servicing.

B. All equipment shall be installed in such a way to maximize access to parts needing service or maintenance. Review the final field location, placement, and orientation of equipment with Fermilab's designated representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with Fermilab's designated representative will result in removal and reinstallation of the equipment at the Subcontractor's expense.

END OF SECTION 15010

SECTION 15080 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 723 - Surface Burning Characteristics of Building Materials
B. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops
C. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)
D. Warnock Hersey - Directory of Listed Products
E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
F. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops
G. NFPA 5000 – Building Construction Safety Code

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.5 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings**:**

    a. Floor penetrations located outside wall cavities.
    b. Floor penetrations located outside fire-resistance-rated shaft enclosures.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

1.6 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Produces Division.
2. Hilti, Inc.
3. RectorSeal Corporation, Metacaulk.
4. Tremco; Sealant/Weatherproofing Division.
5. Johns-Manville.
6. Specified Technologies Inc. (S.T.I.)
7. Spec Seal Firestop Products
8. AD Firebarrier Protection Systems

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Firestopping systems for plumbing and wet pipe sprinkler piping shall be moisture resistant.

E. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

F. Provide firestopping systems allowing continuous insulation for all insulated pipes.

G. Provide firestopping systems classified by UL or listed by Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated
   F Rating = Floor/Wall Rating
   T Rating = Floor/Wall Rating

Penetrating Item	UL System No.
No Penetrating Item	FC 0000-0999*
Metallic Pipe or Conduit	FC 1000-1999
Non-Metallic Pipe or Conduit	FC 2000-2999
Electrical Cables	FC 3000-3999
Cable Trays	FC 4000-4999
Insulated Pipes	FC 5000-5999
Bus Duct and Misc. Electrical	FC 6000-6999
Duct without Damper and Misc. Mechanical	FC 7000-7999
Multiple Penetrations	FC 8000-8999

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated
   F Rating = Wall Rating
   T Rating = 0

Penetrating Item	UL System No.
No Penetrating Item	WL 0000-0999*
Metallic Pipe or Conduit	WL 1000-1999
Non-Metallic Pipe or Conduit	WL 2000-2999
Electrical Cables	WL 3000-3999
Cable Trays	WL 4000-4999
Insulated Pipes	WL 5000-5999

Penetrating Item	UL System No.
Bus Duct and Misc. Electrical	WL 6000-6999
Duct without Damper and Misc. Mechanical	WL 7000-7999
Multiple Penetrations	WL 8000-8999

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated
F Rating = Wall/Floor Rating
T Rating (Floors) = Floor Rating

Penetrating Item	UL System No.
No Penetrating Item	CAJ 0000-0999*
Metallic Pipe or Conduit	CAJ 1000-1999
Non-Metallic Pipe or Conduit	CAJ 2000-2999
Electrical Cables	CAJ 3000-3999
Cable Trays	CAJ 4000-4999
Insulated Pipes	CAJ 5000-5999
Bus Duct and Misc. Electrical	CAJ 6000-6999
Duct without Damper and Misc. Mechanical	CAJ 7000-7999
Multiple Penetrations	CAJ 8000-8999

*Alternate method of firestopping is patching opening to match original rated construction.

H. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

I. Any openings in floors or walls not described in the UL or listed by Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Fermilab, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by Fermilab at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The subcontractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the subcontractor and witnessed by Fermilab and manufacturer's factory representative. Fermilab shall have sole discretion of which firestop system installations will be reviewed. The subcontractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not

be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Fermilab's discretion and the subcontractor's expense.

END OF SECTION 15080

SECTION 15140 - SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.
B. Equipment Bases and Supports.
C. Sleeves and Seals.
D. Flashing and Sealing of Equipment and Pipe Stacks.
E. Cutting of Openings.
F. Escutcheon Plates and Trim.

1.2 REFERENCES

A. ANSI/ASME B31.1 - Power Piping.
B. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
C. NFPA 13 - Standard for the Installation of Sprinkler Systems.
D. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.

1.3 QUALITY ASSURANCE

A. Support Sprinkler Piping in conformance with NFPA 13.

B. Support Standpipes in conformance with NFPA 14.

1.4 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Subcontractor for placement into formwork.

PART 2 - PRODUCTS

2.1 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

Pipe Size	Hanger Rod Diameter Column #1	Column #2
2" and smaller	3/8"	3/8"
2-1/2" through 3-1/2"	1/2"	1/2"
4" and 5"	5/8"	1/2"
6"	3/4"	5/8"
8" through 12"	7/8"	3/4"

Column #1: Cast iron, steel.
Column #2: Copper, plastic.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2.2 PIPE HANGERS AND SUPPORTS

A. All pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS-SP-58 and 127 (where applicable).

B. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.

C. On all insulated piping, provide a semi-cylindrical metallic shield and fire resistant vapor barrier jacket.

D. As an alternative to separate pipe insulation insert and saddle, properly sized integral rigid insulation sections may be used for this application.

Acceptable Products:

Cooper/B-Line -	Fig. B3380 through B3384
Pipe Shields -	A1000, A2000
Erico -	Model 124, 127

E. Support and laterally brace vertical pipes at every floor level in multi-story structures, and more frequently when required by applicable codes (the Illinois Plumbing Code requires 10 foot maximum spacing for support of copper risers), but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings or lugs[JGB1]. Provide sufficient flexibility to accommodate expansion and contraction without compromising fire barrier penetrations and other fixed take-off locations.

Acceptable Products:

Anvil -	Fig. CT121
Cooper/B-Line -	Fig. B3373CT
Erico -	Model 510
Nibco/Tolco -	Fig. 82

F. Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Insulate over mounts.

Acceptable Products: Mason RBA, RCA, or BR.

G. Hangers in direct contact with copper pipe shall be coated with plastic with appropriate temperature range. HYDRA-ZORB clamps are permitted for this application for bare pipes within their temperature limits of -65°F to +275°F.

H. Unless otherwise indicated, hangers shall be as follows:

1. Clevis Type:

Service: Bare Metal Pipe
Rigid Plastic Pipe
Insulated Cold Pipe
Insulated Hot Pipe - 3 inches & Smaller

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Anvil	Fig. 260	
Cooper/B-Line	Fig. 3100	Fig. B3100C
Erico	Model 400	
Nibco/Tolco	Fig. 1	Fig. 81PVC

2. Adjustable Swivel Ring Type:

Service: Bare Metal Pipe - 4 inches and Smaller

Acceptable Products:	Bare Steel Pipe	Bare Copper Pipe
Anvil	Fig. 69	
Cooper/B-Line	Fig. B3170NF	Fig. B3170CTC
Erico	Model FCN	102A0 Series
Nibco/Tolco	Fig. 200	Fig. 203

I. Support may be fabricated from U-Channel strut or similar shapes. Piping less than 4” in in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer’s installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

1. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

J. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

1. Clamp Type:

Service: Bare Metal Pipe
Rigid Plastic Pipe
Insulated Cold Pipe
Insulated Hot Pipe - 3 inches and smaller

a. Clamps in direct contact with copper pipe shall be plastic coated.

b. Pipes subject to expansion and contraction shall have clamps slightly oversized to allow limited pipe movement.

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Unistrut	Fig. P1100 or P2500	
Cooper/B-Line	Fig. B2000 or B2400	Fig. BVT
Nibco/Tolco	Fig. A-14 or 2STR	

K. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

1. Beam Clamps:

Acceptable Products:	
Anvil	Fig. 228, 292
Cooper/B-Line	Fig. B3054
Erico	Model 360
Nibco/Tolco	Fig. 329

2. Concrete Inserts, Single Rod Galvanized:

Acceptable Products:	
Anvil	Fig. 282
Cooper/B-Line	Fig. B3014
Erico	Model 355
Nibco/Tolco	Fig. 310

3. Concrete Inserts, Continuous Strip Galvanized:

Acceptable Products:	
Unistrut Corp	P3200 Series
Cooper/B-Line	Fig. B22-J
Erico	CONCT

4. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-05. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

L. Copper piping located in an exposed area, including indirect waste piping in janitors closets, shall use split ring standoff hangers for copper tubing. Support shall have copper electroplating for corrosion resistance. Use electro-galvanized or more corrosion resistant and threaded rod for floor applications. Use anchors applicable to the wall type with corrosion resistant threaded rod for wall applications.

Acceptable Products:	
Erico/M-Co	Model #456
B-Line	Fig. 3198HCT
Anvil	Fig. CT138R
Nibco/Tolco	Fig. 301CT

M. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs.

N. Welding:

1. Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and for protecting walls and ceilings from being damaged by smoke.

2.3 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Subcontractor) for mechanical equipment.

2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

2.4 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Subcontractor and given to the General Subcontractor for installation or construction as the structure is built.

B. Coordinate all openings with other Subcontractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of Fermilab. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Subcontractor. Failure to coordinate openings with other Subcontractors shall not exempt the Subcontractor from providing openings at his expense.

E. Do not cut structural members without written approval of Fermilab and the Architect or Structural Engineer.

2.5 ROOF PENETRATIONS

A. Seal pipes with surface temperature below 150ºF penetrating single-ply roofs with conical stepped pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots. Material shall match roofing membrane.

B. Break insulation only at the clamp for pipes between 60ºF and 150ºF. Seal outdoor insulation edges watertight.

2.6 SLEEVES AND LINTELS

A. Each Subcontractor shall provide sleeves and lintels for all duct and pipe openings required for the Subcontractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by Fermilab and the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with Fermilab's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Subcontractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

J. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, pipes passing through walls, ceilings, or floors shall have their annular space (sleeve or drilled hole - not tapered hole made with knockout plug) sealed by properly sized sealing elements

consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.

2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve. If piping carries only fluids below 120ºF, sleeves may be thermoplastic with integral water seal and textured surface.

3. Sleeves shall be at least 2 pipe sizes larger than the pipes.

4. Pressure shall be maintained by stainless steel bolts and other parts. Pressure plates may be of composite material for Models S and OS.

5. Sealing element shall be as follows:

Model	Service	Element Material	Temperature Range
S	Standard (Stainless)	EPDM	-40ºF to 250ºF
T	Fire Seals (1 hour)	Silicone	-67ºF to 400ºF
FS	Fire Seals (3 hours)	Silicone	-67ºF to 400ºF

6. Acceptable Manufacturers: Thunderline Corporation "Link-Seals", O-Z/Gedney Company, Calpico, Inc., Innerlynx, or Metraflex Company (cold service only).

2.7 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.8 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.9 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.10 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 PIPE HANGERS AND SUPPORTS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.

2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.

3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

B. Supports Requirements:

1. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.

2. Set all concrete inserts in place before pouring concrete.

3. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.

4. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

5. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.

2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.

4. Piping shall not introduce strains or distortion to connected equipment.

5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.

6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.

7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.

8. Provide at least one hanger adjacent to each joint in cast iron soil pipe, and grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3'spacing between loads.

2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

a. The hanger is attached within 6" from a web/chord joint.

b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.

4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Fermilab.

E. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

F. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

G. Spacing of Hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

Pipe Material	Maximum Spacing
1. Steel (Std. Weight or Heavier – Liquid Service):	
1-1/4" & under	7'-0"
1-1/2"	9'-0"
2"	10'-0"
2-1/2"	11'-0"
3"	12'-0"
4" & larger	12'-0"
2. Hard Drawn Copper & Brass (Liquid Service):	
3/4" and under	5'-0"
1"	6'-0"
1-1/4"	7'-0"
1-1/2"	8'-0"
2"	8'-0"
2-1/2"	9'-0"
3. Cast Iron Soil Pipe - All Sizes:	
Over 5' pipe lengths	10'-0"
Less than 5' pipe lengths	5'-0"
Support all direction changes and branch connections.	

4. Rigid Plastic Pipe:

   a. Space hangers at 4’-0” maximum centers.

5. Installation of hangers shall conform to MSS SP-58 and the applicable Plumbing Code.

END OF SECTION 15140

SECTION 15163 - SUMP PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Sump Pumps.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 15010.

B. Submit certified pump performance curves with pump and system operating point plotted. Include NPSH curve when applicable.

C. Pumps with motors operating above the RPM the pump curves are based on shall have impellers trimmed to deliver GPM and head scheduled.

PART 2 - PRODUCTS

2.1 GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking piping or motor connections.

C. Pumps shall operate at 1750 rpm unless specified otherwise.

D. Pump connections shall be flanged, whenever available.

E. Motors shall comply with Section 15170.

F. The discharge pipe sizes shall meet or exceed the scheduled pump.

2.2 SUMP PUMPS

A. Provide pumps as specified on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings and accessories.

C. Support piping so weight of piping is not supported by pumps.

D. Mount control panel on adjacent wall within required distance for cables and wiring. Provide unistrut mounting frame for the control panel if wall space is not available. Properly anchor frame to floor.

E. Ensure pumps operate at specified fluid temperatures without vapor binding or cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.

F. Pumps shall be factory aligned. If alignment is not satisfactory, as determined by Fermilab, manufacturer shall provide a factory trained representative to field align the shafts.

G. Sump pumps that discharge to storm shall be installed with the top of the sump basin 18” above floor level. A 18” high x 4” wide concrete curb around the perimeter of the basin lid may be used in lieu of raising the entire sump basin.

H. Set submersible sump pumps on basin/pit floor. Make direct connections to storm drainage piping.

I. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

END OF SECTION 15163

SECTION 15170 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 REFERENCES

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. ANSI/NEMA MG 1 - Motors and Generators.

E. ANSI/NFPA 70 - National Electrical Code.

F. Energy Independence and Security Act of 2007.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 15010. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for all three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding device for all motors as required.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics.

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Variable Speed AC Vector Duty Motors: Totally Enclosed Non-Vented (TENV) suitable for operation on fans and designed for adjustable speed applications where up to 1000:1 constant torque speed range may be required. Compatible with VFD operation and suitable for across the line operation in the event that drive is in bypass mode. Use only where specified on drawings and confirm compatibility with drive and equipment.

D. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

E. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

F. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

G. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

H. Each subcontractor shall set all motors furnished by him.

I. All motors shall have a minimum service factor of 1.15 unless specified otherwise on drawings.

J. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

K. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

L. Aluminum end housings are not permitted on motors 15 HP or larger.

M. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

N. Motors for fans 1/12 HP or greater and less than 1 HP shall be electronically-

commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed.

2.2 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Full-Load Efficiencies %					
	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7
30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.00	94.1	94.5	93.0	94.1	94.5	93.0

B. Motor nameplate shall be noted with the above ratings.

2.3 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor unless specified otherwise on drawings. Motors shall <u>not</u> be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, “Performance Standards Applying to All Machines,” Part 31 “Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 460 volt motors controlled by VFDs shall be equipped with an alternate discharge path, such as a shaft grounding ring or grounding brush, to divert adverse shaft currents from the motor bearings on the drive end of the motor

shaft. Motor shafts 2” and larger require shaft grounding on the drive end and the non-drive end. This Subcontractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.

2.4 MOTOR DRIVEN EQUIPMENT

A. No equipment shall be selected or operate above 90% of its motor nameplate rating unless specified otherwise on drawings. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.

B. If a larger motor than specified is required on equipment, the subcontractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

2.5 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Subcontractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Subcontractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer’s recommendations. Align shafts to manufacturer’s requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION 15170

SECTION 15190 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 15.

1.2 REFERENCES

A. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.

B. ASTM B-1, B-3, and B-8 for copper conductors.

C. ASTM D-1248 for Polyethylene Extrusion Materials, ICEA S-70-547 Weatherproof Resistant Polyethylene Conductors, ICEA S-61-402/NEMA WC5 Thermoplastic Insulated Wire & Cable, ICEA S-95-658/NEMA WC70 Non-Shielded 0 – 2kV Cables.

D. UL 1581 Standard for Electrical Wires, Cables, and Flexible Cords.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M, Bunting, Calpico, Craftmark, Emedco, Kolbi Industries, Seton, W.H. Brady, Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

O.D. of Pipe or insulation	Marker Length	Size of Letters
Up to and including 1-1/4”	8”	1/2”
1-1/2” to 2”	8”	3/4”
2-1/2” to 6”	12”	1-1/4
8” to 10”	24”	2-1/2”

Plastic tags may be used for outside diameters under 3/4".

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Aluminum Nameplates: Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

D. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4” minimum black letters on light contrasting background.

E. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2".

F. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

G. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

H. Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape 6" wide by 3.5 mils thick, manufactured for direct burial, with aluminum foil core for location by non-ferric metal detectors and bold lettering identifying buried item.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer’s recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.

2. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.

3. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.

4. Number all tags and show the service of the pipe.

5. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by Fermilab.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.

2. Apply markers and arrows in the following locations where clearly visible:

a. At each valve.
b. On both sides of walls that pipes penetrate.
c. At least every 20 feet along all pipes.

d. On each riser and each leg of each "T" joint.
e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as rooftop units, exhaust fans, filters, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.

2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.

3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

3.2 SCHEDULE

A. Pipes to be marked:

Pipe Service	Lettering Color	Background Color
Domestic Cold Water	White	Green
Domestic Hot Water - 115°F	Black	Yellow
Domestic Hot Water - 140°F	Black	Yellow
Sanitary Sewer	Black	Yellow
Vent	Black	Yellow
Storm Sewer	White	Green
Natural Gas	Black	Yellow
Fire Protection Water	White	Red
Sprinkler Water	White	Red
All Underground Pipes	Varies	Varies

B. All piping downstream of the fire protection service entrance to the building, upstream of sprinkler zone valves, standpipe piping, and combination sprinkler standpipe piping shall be labeled Fire Protection Water. All piping downstream of sprinkler zone valves shall be labeled Sprinkler Water.

END OF SECTION 15190

SECTION 15245 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.
B. Vibration Isolation.
C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 15010 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio – for spring isolators)
13. Materials and Coatings
14. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENTS

A. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

B. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3" for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

C. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

D. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

E. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

F. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

G. Provide motor slide rails for belt-driven equipment per Section 15170.

H. All isolators, except M1, shall have provision for leveling.

2.2 MOUNTINGS

A. Type M2:

1. Double deflection neoprene with minimum static deflection of 0.15" at calculated load and 0.35" at maximum rated load.

2. All metal shall be neoprene covered. Mounting shall have friction pads both top and bottom.

3. All units shall have bolt holes and be bolted down.

4. Use steel rails above the mountings to compensate for the overhang of equipment such as small vent sets and close coupled pumps.

5. Acceptable Manufacturers: Mason Industries "ND" or "DNR", Amber/Booth "RVD", Kinetics "RD", Vibration Mountings and Controls "RD", Vibration Eliminator Co. “T22” or “T44”.

B. Type M3:

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.

2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.

3. All mountings shall have leveling bolts.

4. Acceptable Manufacturers: Mason "SLFH", Kinetics "FDS", Amber/Booth "SW-3, 4", 5"or 6", Vibration Eliminator Co. "OST".

C. Type M4:

1. Use restrained spring mountings for equipment with operating weight different from the installed weight such as chillers and boilers, and equipment exposed to the wind such as cooling towers.

2. Spring isolators shall be free-standing with 1/4" neoprene acoustical friction pads.

3. All units shall have bolt holes and be bolted down. Prevent short circuiting with neoprene bushings and washers between bolts and isolators.

4. All mountings shall have leveling bolts.

5. Housings with vertical resilient limit stops shall prevent spring extension when weight is removed. Housings shall serve as blocking during erection and the installed and operating heights shall be the same.

6. Maintain a minimum clearance of 1/2" around restraining bolts and between the housings and the springs so as not to interfere with the spring action.

7. Limit stops shall be out of contact during normal operation.

8. Select isolators for equipment subjected to wind loads in conformance with ASCE 7-02.

9. Acceptable Manufacturers: Mason "SLRS", Kinetics "FLS", Aeroflex "AWRS", Vibration Eliminator Co. "KW".

2.3 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.

2. Static deflection shall be at least 0.15" at calculated load and 0.35" at maximum rated load.

3. Provide hangers with end connections as required for hanging ductwork or piping.

4. Acceptable Manufacturers: Mason "HD" or "WHD", Kinetics "RH", Aeroflex "RHD", Vibration Eliminator Co. “ALH”.

B. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.

2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.

3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc before contacting the grommet and short circuiting the spring.

4. Provide end connections for hanging ductwork or piping.

5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.

6. Deflection shall be indicated by a pointer and scale.

7. Acceptable Manufacturer: Mason "PC30", Kinetics “SFH”, Amber/Booth “BSW”, Vibration Eliminator Co. “PCS”.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer’s recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first three hangers from vibration-isolated equipment shall be type H1.

B. Where piping is floor-supported, use M2 instead of H1.

C. Provide sufficient piping flexibility for vibrating refrigerant equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

D. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

3.3 VIBRATION ISOLATION OF DUCTWORK

A. The first three hangers on all fan systems shall be Type H1 with at least 0.20” minimum static deflection.

B. Provide flexible duct connections as described in Section 15910 at all fan inlets and outlets and on the mechanical room side of all locations where ducts penetrate mechanical room walls.

3.4 VIBRATION ISOLATION SCHEDULE

EQUIPMENT DESIGNATION	**BASE TYPE**	**ISOLATOR TYPE**	**STATIC DEFLECTION**	**FLEXIBLE CONNECTIONS**
Packaged HVAC Unit (>15 HP, <4” static pressure)	NA	M3	0.75”	Per Specification Section 15910

VIBRATION ISOLATION SUBMITTAL FORM											
COLUMN 1	2	3	4	5	6	7	8	9	10	11	12
		PROPOSED ISOLATOR							CALCULATIONS		
ITEM SERVED	MIN DEFL (")	TAG	MODEL	MAX LOAD (#)	DEFL @ MAX LOAD (")	DEFL TO SOLID (")	FREE HT (")	Kx/Ky	LOAD (#)	DEFL (")	DEFL RATIO

1. Item served should match designation on the design drawings.
2. List the deflection scheduled or specified in the design documents.
3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.
4. List the manufacturer's complete model designation for the isolator.
5. List the manufacturer's maximum rated load for the isolator.
6. List the isolator deflection at the maximum rated load in column 5.
7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.
8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.
9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.
10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.
11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).
12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.

GENERAL NOTES:

1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.

END OF SECTION 15245

SECTION 15260 - PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.
B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required).

1.3 REFERENCES

A. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ANSI/ASTM C195 - Mineral Fiber Thermal Insulation Cement.

C. ANSI/ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

D. ANSI/ASTM C547 - Mineral Fiber Preformed Pipe Insulation.

E. ANSI/ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.

F. ASTM B209 - Aluminum and Aluminum-alloy Sheet and Plate.

G. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

H. ASTM E84 - Surface Burning Characteristics of Building Materials.

I. NFPA 255 - Surface Burning Characteristics of Building Materials.

J. UL 723 - Surface Burning Characteristics of Building Materials.

K. National Commercial & Industrial Insulation Standards - 1999 Edition - as published by Midwest Insulation Subcontractors Association and endorsed by National Insulation Subcontractors Association.

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75ºF; non-combustible. All purpose, white kraft jacket bonded to aluminum foil and reinforced with fiberglass yarn, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).

B. Type C: Molded rigid cellular glass; ANSI/ASTM C-552; 0.35 maximum 'K' value at 75ºF; moisture resistant, non-combustible; suitable for -100ºF to +900ºF. For below grade installations use asphaltic mastic paper vapor barrier jacket. Use self-seal all-purpose white kraft jacket for above grade installations.

C. Type E: Hydrous Calcium Silicate; ASTM C533; rigid molded pipe insulation; asbestos free; 0.40 'K' value at 300ºF; 1200ºF maximum service temperature; 16 gauge stainless steel tie wires on maximum 12" centers.

2.2 VAPOR BARRIER JACKETS

A. Kraft reinforced foil vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM B209; 0.016" thick; stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

B. Stainless Steel Jackets: Type 304 316 stainless steel; 0.010" thick; smooth finish with Z edge seams and stainless steel bands for outdoor use.

C. Plastic Jackets and Fitting Covers: High impact, glossy white, 0.020" 0.030" thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40ºF to 150ºF. 25/50 maximum flame spread/smoke developed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.

2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.

3. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a 180° cylindrical segment the same length as metal shields. Inserts shall be a cellular glass (for all temperature ranges) or molded hydrous calcium silicate (for pipe with operating temperatures above 70°F, with a minimum compressive strength of 50 psi. Factory fabricated inserts may be used. Rectangular blocks, plugs, or wood material are not acceptable. Temporary wood blocking may be used by the Piping Subcontractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Subcontractor.

4. Neatly finish insulation at supports, protrusions, and interruptions.

5. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

6. Shields shall be at least the following lengths and gauges:

	Pipe Size	Shield Size
a.	1/2" to 3-1/2"	12" long x 18 gauge
b.	4"	12" long x 16 gauge
c.	5” to 6"	18" long x 16 gauge

7. All piping and insulation that does not meet 25/50 that is located in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has passed ASTM E84 and/or NFPA 255 testing with a rating of 25/50 or below.

8. On 1" and smaller piping routed through metal wall studs, provide a plastic grommet to protect the piping. The piping shall be insulated between the wall studs, and the insulation shall butt up to each stud.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, strainers, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.

2. All balance valves with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow reading and adjusting of the valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Exposed Piping:

1. Locate and cover seams in least visible locations.

2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3. On exposed piping serving plumbing fixtures, the piping does not need to be insulated if less than four feet in developed length. If piping is longer than four feet in developed length, the piping shall be insulated and have a plastic jacket.

3.3 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.

2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.

3. Apply insulation with laps on top of pipe.

4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60ºF, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type C Insulation:

1. Seal all longitudinal joints with manufacturer approved adhesive. Secure butt joint strips in a similar manner.

2. Insulate fittings with prefabricated fittings.

C. Type E Insulation:

1. Use pre-molded half sections. Butt longitudinal and circumferential joints tightly. Wire in place with 16 gauge stainless steel wire on maximum 12" centers.

2. Apply in two layers. Stagger all joints between layers. Wire each layer individually.

3.4 JACKET COVER INSTALLATION

A. Metal Covering:

1. Provide vapor barrier as specified for insulation type. Cover with stainless steel jacket covering with seams located on the bottom of horizontal piping. Include fittings, joints and valves.

2. Seal all interior and exterior butt joints with metal draw bands and sealant. Seal all exterior joints watertight.

3. Interior joints do not need to be sealed.

4. Use metal covering on the following pipes:

   a. All exterior piping.
   b. Cover insulation with aluminum jacketing.
   c. All Type E insulation.

B. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.

2. Solvent weld all joints with manufacturer recommended cement.

3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.

4. Use plastic insulation covering on all exposed pipes including, but not limited to:

   a. All exposed piping below 8'-0" above floor.

3.5 SCHEDULE

Piping System	Insulation Type/Thickness
A. Domestic Hot Water - up to 140°F	
Up to 1-1/2" Pipe Size	A / 1”
Above 1-1/2" Pipe Size	A / 1-1/2”
B. Domestic Cold Water	A / 1”
C. Domestic Hot & Cold Water up to 1-1/2” (concealed in walls)	A / 1/2”
D. Storm Drainage (all piping within the building, except underground)	A / 1”
E. Plumbing Vents Within 10' from Roof Penetration	A / 1/2”

Piping System	Insulation Type/Thickness
F. Insulation Inserts at hangers	C or E - Match pipe insulation thickness

END OF SECTION 15260

SECTION 15290 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Insulation.
B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five years minimum experience. When requested, installer shall submit manufacturer's certificate indicating qualifications.

B. Materials: UL listed in Category HNKT; flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723.

C. Adhesives: UL listed, meeting NFPA 90A/90B requirements.

1.3 REFERENCES

A. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

C. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM E84 - Surface Burning Characteristics of Building Materials.

E. ASTM E136 - Standard Test Method for the Behavior of Materials in a Vertical Tube Furnace at 750°C.

F. ASTM E814 - Fire Tests of Through Penetrations Firestops.

G. National Commercial & Industrial Insulation Standards - 1999 Edition - as published by Midwest Insulation Contractors Association and endorsed by National Insulation Contractors Association.

H. NFPA 255 - Surface Burning Characteristics of Building Materials.

I. UL - XHEZ - Through Penetration Firestop Systems.

J. UL 263 - Full Scale External Fire Tests with Hose Stream.

K. UL 723 - Surface Burning Characteristics of Building Materials.

L. UL 1479 - Fire Tests of Through Penetrations Firestops.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type B: Semi-rigid Fiberglass Board Wrap - Outside Application; ANSI/ASTM C612, Class 1; 0.25 maximum 'K' value at 75°F; foil scrim kraft facing, 3 lb./cu. ft. density.

B. Type C: Flexible Fiberglass Liner; ANSI/ASTM C1071; 0.28 maximum 'K' value at 75°F; 1.5 lb/cu ft minimum density; coated air side for 4000 fpm air velocity.

C. Type G: Preformed rigid fiberglass acoustical liner. ANSI/ASTM C1071; 0.23 maximum ‘K’ value at 75°F mean temperature; Noise Reduction Coefficient (NRC) per ASTM C423 Type “A” mounting of 0.70 0.75 for 1” thickness, 0.90 for 1.5” thickness. Liner shall be factory coated with an anti-microbial agent to prevent fungus and bacteria growth per ASTM G-21 and G-22. Max flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723.

2.2 JACKETS

A. Vapor Barrier Jackets: Kraft reinforced foil scrim vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 25 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM B209; 0.016" thick; smooth or embossed stucco finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

B. Stainless Steel Jackets: Type 304 316 stainless steel; 0.010" thick; smooth finish with Z edge seams and stainless steel bands for outdoor use.

C. Laminated 5 ply, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane having high performance acrylic adhesive capable of installation with no additional mechanical attachment. Fermilab/Architect shall select from manufacturer’s standard finishes. For areas exposed to high traffic or rough service, where scheduled or where shown on the drawings, use 13 ply heavy duty protective jacketing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with manufacturer's instructions, codes, and industry standards.

B. Install materials after ductwork has been tested.

C. Clean surfaces for adhesives.

D. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

E. Semi Rigid Fiberglass Board Wrap - Type B (Indoor Use):

1. Impale on pins welded to the duct and secured with speed clips. Clip pins off close to speed clips.

2. Space pins as needed to hold insulation firmly against duct, but not less than one pin per square foot. Pins must be long enough to avoid compressing the insulation.

3. Seal all joints and speed clips with glass fabric set in adhesive or a 3" wide strip of Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK facing tape.

4. For small areas, secure insulation with adhesive over the entire surface of the duct. Use adhesive in addition to pins as needed to prevent sagging on horizontal surfaces.

F. Semi Rigid Fiberglass Board Wrap - Type B (Outdoor Use):

1. Impale on pins welded to the duct and secured with speed clips. Clip pins off close to speed clips.

2. Space pins as required to hold insulation firmly against duct, but not less than one pin per square foot. Pins must be long enough to avoid compressing the insulation.

3. Seal all joints and speed clips with glass fabric set in adhesive or a 3" wide strip of the same facing tape with adhesive.

4. For small areas, secure insulation with adhesive over the entire surface of the duct. Use adhesive in addition to pins as needed to prevent sagging on horizontal surfaces.

5. Install vapor barrier jacket. Cover with aluminum stainless steel colored aluminum laminated jacket covering with seams on the bottom of horizontal ductwork.

6. Seal all butt joints with metal draw bands screwed to jacket and filled with sealant. Seal all joints watertight.

7. Provide positive slope on top of all horizontal surfaces to prevent ponding of water.

G. Interior Insulation - Flexible Duct Liner, Type C:

1. Observation of Duct Lining:

   a. After installation of ductwork, Fermilab may select random observation points in each system.

      1) At each observation point, cut and remove an 18" x 18" section of ductwork and liner for verification of installation.

      2) Random observation points based on one opening per 75 lineal ft. of total duct run.

   b. When any of the observation points shows non-compliance, additional points will be designated by Fermilab, and observation repeated.

   c. If 20% of points observed do not comply, remove and replace all lined ducts and repeat tests. Where replacement is not required, correct all non-compliances.

   d. At end of observation, repair all duct lining and observation holes by installing standard, insulated, hinged access doors per Section 15910.

   e. Paint or finish to match adjacent duct surfaces.

2. Impale on spindle anchors welded or mechanically fastened to the duct. Adhesive or glue fastened anchors are not acceptable. Maximum anchor spacing per SMACNA Duct Construction Standards or manufacturer's recommendations, whichever is more restrictive. Locate pins less than 3" from corners and at intervals not over 6" around the perimeter at leading and trailing edges. Locate pins within 3" of transverse joints and at intervals not over 16" long the length of the duct. Pins must be long enough to prevent compressing the insulation.

3. In addition to anchors, secure liner with UL listed adhesive covering over 90% of the duct surface.

4. Install per the latest edition of the SMACNA Manual.

5. Leading edges shall be covered as follows:

   a. For duct velocities below 3000 fpm, coat leading edges with adhesive. Neatly butt liner without gaps at transverse joints. Cut liner flush with end of the duct section for tight joints with no exposed duct. If adhesive is shop installed, field apply additional adhesive to the end of each duct section for complete adhesion of the liner. Protect edges from dirt and debris.

   b. For duct velocities above 3000 fpm, cover leading edges with metal nosing. Use nosing on upstream edges of each section of duct. If the duct can be installed in either direction, provide nosing

on each end or clearly mark the duct to allow visual verification after installation. Verify duct velocities based on the scheduled air flow rates and determine where metal nosing is required.

c. Install metal nosing in the following locations (regardless of velocity):

1) The first three fittings downstream of all fans.
2) At all duct liner interruptions. This includes fire dampers, access doors, branch connections, and all other locations where the edge of the liner is exposed.
3) Trailing edges of transverse joints do not require metal nosings.

6. Overlap liner at longitudinal joints. Make longitudinal joints at corners of the duct unless the duct size does not allow this. Coat longitudinal joints with adhesive at velocities over 2500 fpm.

7. Seal all damaged duct liner with adhesive and glass cloth. Do not damage duct liner surface coatings.

8. Duct dimensions given are net inside dimensions. Increase sheet metal to allow for insulation thickness.

H. Preformed Fiberglass Acoustical Liner, Rigid - Type G:

1. Cut and secure duct liner inside duct.

2. Install insulation pins or adhesives in locations as recommended by the manufacturer.

3. Seal all damaged duct liner and fill all gaps with manufacturer approved sealant. Do not damage duct liner surface coatings.

4. Where edges show evidence of delamination, the damaged areas shall be secured by manufacturer approved sealant.

5. Duct dimensions given are net inside dimensions. Increase sheet metal to allow for insulation thickness.

I. Continue insulation with vapor barrier through penetrations unless code prohibits.

J. Provide 2" wide, 24" high, 26 gauge, galvanized sheet metal corner protection angles for all externally insulated ductwork extending to a floor or curb.

3.2 SCHEDULE

A. Refer to Section 15890 for scheduling of insulation.

END OF SECTION 15290

SECTION 15310 - FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe, Fittings, Valves, and Connections for Fire Protection System.
B. Wet-Pipe Sprinkler System.
C. Standpipe System.

1.2 QUALITY ASSURANCE

A. Welding Materials and Procedures: Conform to ASME Code.

B. Equipment and Components: Bear UL label or marking.

C. Valves: Bear UL label or marking. Provide manufacturer's name and pressure rating marked on valve body. Pressure rating shall match specified pipe system pressure rating. Remanufactured valves are not acceptable.

D. Specialist Firm: Company specializing in sprinkler systems with minimum three years experience.

E. Sprinkler design drawings submitted by the subcontractor shall be designed, certified, and shall include the NICET certification block or the Professional Engineer seal of the fire protection designer. Fire protection designer shall be NICET Level III or Level IV certified or be a licensed Professional Engineer.

1.3 REFERENCES

A. ANSI/ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.

B. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings, Class 150 and 300.

C. ANSI/ASME B16.4 - Cast Iron Threaded Fittings, Class 125 and 250.

D. ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings.

E. ANSI/ASME B16.9 - Factory-made Wrought Steel Butt-Welding Fittings.

F. ANSI/ASME B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.

G. ANSI/ASME B16.25 - Butt-Welding Ends.

H. ANSI/ASME B36.10 - Welded and Seamless Wrought Steel Pipe.

I. ANSI/ASME Section 9 - Welding and Brazing Qualifications.

J. ANSI/ASTM A47 - Malleable Iron Castings.

K. ANSI/ASTM A135 - Electric-Resistance-Welded Steel Pipe.

L. ANSI/AWWA C110 - Ductile Iron and Gray Iron Fittings.

M. ANSI/AWWA C151 - Ductile Iron Pipe, Centrifugally Cast.

N. ASME - Boiler and Pressure Vessel Code - Section IX, Welding and Brazing Requirements.

O. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-coated Welded and Seamless.

P. AWS A5.8 - Brazing Filler Metal.

Q. AWS B2.2 - Standard for Brazing Procedure and Performance Qualification.

R. AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.

S. MSS SP-73 - Brazing Joints for Wrought and Cast Copper Alloy Solder Joint and Pressure Fittings.

T. NFPA 101 - Life Safety Code.

U. NFPA 13 - Installation of Sprinkler Systems.

V. NFPA 14 - Standpipe and Hose Systems.

W. NFPA 25 - Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.

X. UL - Underwriter's Laboratory Fire Protection Equipment Directory.

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010. Indicate pipe materials, joining methods, supports, floor and wall penetration seals, sprinklers, equipment data and ratings, and hydraulic calculations.

B. Submit detailed pipe and sprinkler layout and other calculations and forms as described in NFPA 13.

C. Submit detailed working drawings and obtain review of them in the following order:

1. Engineer/Architect.
2. State Fire Marshal/Authority Having Jurisdiction
3. Fermilab's Insurance Company
4. Fermilab

Begin construction after all approvals are received.

D. Working drawings shall include piping and sprinkler layout, sprinkler types and ratings, sections and elevations at critical points. Show coordination with lighting, ductwork, and diffusers, and indicate basic flow and hydraulic design information, including main location and date that the test was taken.

E. Provide Fermilab with one copy of NFPA 25. *Standard for the Inspection Testing and Maintenance of Water-based Fire Protection Systems.*

1.5 EXTRA STOCK

A. Provide metal storage cabinet, wrenches for each sprinkler type, and extra sprinklers per NFPA 13 and applicable building code.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store valves and sprinklers in shipping containers, with labels in place.

B. Provide temporary protective coating on iron and steel valves.

C. Maintain temporary end caps and closures in place until installation.

1.7 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves to General Subcontractor for placement in walls and floors. Sleeve location to be determined by the Fire Protection Subcontractor prior to construction. If additional sleeves are required, they shall be core drilled by the Fire Protection Subcontractor.

1.8 SYSTEM DESCRIPTION

A. System shall cover building areas noted.

B. System shall interface with building fire alarm system. Provide all required wiring.

C. Provide wet pipe sprinkler system to NFPA 13 and building code requirements as required by Fermilab's insurance company and as shown on the drawings. Provide standpipe system to NFPA 14 and building code requirements as required by Fermilab's insurance company and as shown on the drawings.

D. Provide a Fire Department connection.

1.9 REGULATORY REQUIREMENTS

A. All material, equipment, and installation shall be approved by the Authorities Having Jurisdiction and Fermilab's Insurance Company.

B. The Authorities Having Jurisdiction and Fermilab's Insurance Company shall have precedence over the drawings and specifications in case of discrepancies.

C. The entire installation shall comply with all applicable codes.

1.10 SYSTEM DESIGN

A. Design and install a complete, hydraulically calculated wet-pipe sprinkler system for the entire building. Design and install a complete, hydraulically calculated standpipe system for the entire building.

B. Provide all required equipment and accessories.

C. System shall include a 5 psi allowance for future decrease in available pressure and an allowance for inside and outside hose streams.

D. Provide monitor switches on all shutoff valves.

E. Install sprinkler riser in location shown on drawings or as approved by Fermilab.

F. Provide service shutoff valve in the sprinkler main with a wall indicator assembly.

G. Provide pressure gauge with valve in the main riser.

H. Provide main drain valve piped to outside the building. Locate so discharge does not damage lawn or other surfaces.

I. Provide flow switch in the main riser and as indicated on drawings.

1.11 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 15010 for required fire protection systems electronic CAD drawings to be provided to Coordinating Subcontractor for inclusion into composite coordination drawings.

1.12 OPERATION AND MAINTENANCE DATA

A. Submit manufacturers' operation and maintenance data. Include written maintenance data on components of system, servicing requirements, and record drawings.

1.13 JOB CONDITIONS

A. Fire Protection Subcontractor shall determine the flow and pressure available at the service connection. The Fire Protection Subcontractor is responsible to verify this information and make all tests required. Base all pipe sizing and hydraulic calculations on flow test data no older than 18 months.

B. Pipe sizing shown on drawings for service entrance and main risers is preliminary for coordination purposes only. Subcontractor is responsible for final sizing from hydraulic calculations.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Steel Pipe (Inside Building-Above Grade):

1. Pipe: 2" and Under - Schedule 40, black steel, ASTM A53. Threaded and coupled or flanged.

2. Joints: 2" and under - screwed or flanged.

3. Fittings: Screwed - cast iron, 125 lb., black, ANSI/ASME B16.4 or malleable iron, 150 lb., black, ANSI/ASME B16.3. Flanged-cast iron, 125 lb., ANSI/ASME B16.1.

B. Steel Pipe (Inside Building-Above Grade):

1. Pipe: 2-1/2" and Over - Schedule 40, black steel, grooved, ASTM A53.

2. Joints: Mechanically coupled grooved.

3. Fittings: 500 lb. WOG, black, malleable iron, ASTM A47.

4. Plain end fittings and couplings are not acceptable.

C. Fire Protection Service to Building (by others):

1. Refer to Section 15410.

2.2 UNIONS AND COUPLINGS

A. Unions: 175 psi malleable iron for threaded ferrous piping.

B. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular and longitudinal deflection; “C” shaped composition sealing gasket, steel bolts, nuts, and washers. 175 psi, ASTM A47. Plain end fittings and couplings are not acceptable. Rolled groove couplings for Schedule 10 pipe. Cut groove couplings for Schedule 40 pipe. Couplings shall be enamel coated for wet systems. Acceptable Manufacturers: Victaulic, ITT, Grinnell, Central, Anvil GruvLok, Star Fittings.

C. Coupling gaskets for wet systems shall be Grade “E” EDPM Type A.

2.3 VALVE OPERATORS

A. Provide handwheels for gate valves. Provide gear operators for butterfly valves.

2.4 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe.

2.5 EQUIPMENT

A. Equipment shall be as scheduled on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION - PIPING

A. General Installation Requirements:

1. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over sprinkler piping and sprinklers.

2. Ream pipe and tube ends to full inside diameter. Remove burrs. Remove scale and foreign material, inside and outside, before assembly.

3. Die cut screw joints with full cut standard taper pipe threads.

4. Coat threads with pipe joint compound or wrap with Teflon tape.

5. Locate piping to minimize obstruction of other work.

6. Route piping in concealed spaces above finished ceiling.

7. Use full and double lengths of pipe wherever possible.

8. Slope all piping for complete drainage. Install auxiliary drains for all trapped piping per NFPA 13.

9. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

10. Comply with manufacturer's installation instructions.

B. Steel Piping:

1. In steel piping, main sized saddle branch connections or direct connection of branches to main is permitted if main is one pipe size larger than the branch for up to 6" mains and if main is two pipe sizes larger than branch for 8" and larger mains. Do not project branch pipes into main pipes.

C. Wall/Floor Penetration:

1. Provide sleeves when penetrating floors and walls.

2. Seal pipes passing through exterior walls with a wall seal per Section 15140. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe. Sleeves through floors shall extend minimum 1.5" above finished floor.

3. Fire seal all pipe and sleeve penetrations (both wall and floor) to maintain fire separation required without restraining pipe.

D. Installation Requirements in Electrical Equipment Areas:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment. Fire protection equipment dedicated to the electrical equipment room or space may be installed above equipment if other alternatives are not available.

E. Hangers and Supports:

1. Provide hangers and supports as required by NFPA 13 and UL, with the following exceptions:

a. Do not use powder driven devices, explosive devices, wooden plugs, or plastic inserts.

b. Do not install fasteners to carry the load in tension, unless absolutely necessary.

F. Exposed Piping:

1. Install chrome plated steel escutcheons where exposed pipes penetrate walls or floors.

3.2 INSTALLATION - VALVES

A. Shutoff Valve:

1. Provide drain valves at main shutoff valves, low points of piping and apparatus.

3.3 INSTALLATION - EQUIPMENT

A. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over system equipment and sprinklers.

B. Fire Department Connection:

1. Locate fire department connection in an accessible location as approved by the local fire department with sufficient clearance from walls, obstructions, and adjacent Siamese connectors to allow full swing of fire department wrench handle.

C. Test Valves:

1. Install test valves where required. Pipe to outdoors or drain. Test connection shall have flow equivalent to the smallest K-factor sprinkler.

D. Sprinklers:

1. Locate sprinklers to clear lights, ducts and diffusers. Do not run sprinkler pipes through ducts. Ductwork has priority over sprinkler pipes. Offset pipes as needed.

2. Center sprinklers in two directions in ceiling tiles and provide offsets as required.

3. Do not allow concealed sprinkler cover plates to be painted. Sprinkler cover plates are to be factory painted only. Do not field paint.

4. Apply strippable or paper covers so concealed sprinkler cover plates do not receive field paint finish.

3.4 INSTALLATION - STANDPIPE AND HOSE SYSTEM

A. Locate and secure hose cabinet plumb.

B. Locate angle valve in cabinet at 60" above floor. Locate fire department connection below angle valve and not closer than 4" from side or bottom of cabinet.

C. Where static pressure exceeds 175 psig at any hose station, provide pressure regulating valves to limit the pressure on hose to 100 psi.

D. Provide connection for alarm and supervisory control to building alarm system.

3.5 SYSTEMS CLEANING AND TESTING

A. General Requirement:

1. All water used for testing and remaining in the piping system shall be obtained from a potable water source.

B. Underground Piping:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

a. 390 gpm for 4" pipes.
b. 880 gpm for 6" pipes.

2. Branches from existing or new underground mains to sprinkler risers shall be flushed out through two 2-1/2" hoses (with flow through open hose butts) attached to the riser with 4" temporary piping. Flushing through the drain of an alarm check or dry pipe valve is not acceptable.

C. Interior Piping:

1. Verify adequate water flow at the inspector's test connection.

2. Flush all interior piping to remove scale and other foreign material before placing system into service.

3. Hydrostatically test the entire interior piping system at a minimum of 200 psig or 50 psig in excess of the normal system working pressure for systems subjected to pressures in excess of 150 psig. Maintain test pressure for 2 hours without loss of pressure.

D. Standpipe and Hose Systems:

1. Hydrostatically test standpipe and hose systems in accordance with NFPA 14 and applicable building code requirements.

E. Fire Alarm System:

1. Test the alarm system by operating the inspector's test connection or the alarm test valves. Verify that the building fire alarm system activates.

2. Adjust all monitor switches for proper operation.

END OF SECTION 15310

SECTION 15410 - PLUMBING PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Domestic Water Piping System.
D. Sanitary Drainage and Vent Piping System.
E. Storm Drainage Piping System.
F. Footing Tile.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

D. Piping, Fittings, Valves, and Flux for Potable Water Systems: All components shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act.

1.3 REFERENCES

A. ANSI/ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings.

B. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.

C. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.

D. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 NS 300.

E. ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings.

F. ANSI/ASME B16.9 - Factory-Made Wrought Steel Butt Welding Fittings.

G. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.

H. ANSI/ASTM B32 - Solder Metal.

I. ANSI/ASTM D2466 - PVC Plastic Pipe Fittings, Schedule 40.

J. ANSI/AWS D1.1 - Structural Welding Code.

K. ANSI/AWWA C110 - Ductile Iron and Gray Iron Fittings 3" through 48", for Water and Other Liquids.

L. ANSI/AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings.

M. ANSI/AWWA C151 - Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.

N. ANSI/AWWA C153 – Compact Ductile Iron Fittings 3” through 48”, for Water and Other Liquids.

O. ASME - Boiler and Pressure Vessel Code.

P. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

Q. ASTM A74 - Hub and Spigot Cast Iron Soil Pipe and Fittings.

R. ASTM A674 - Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids.

S. ASTM A888 - Hubless Cast Iron Soil Pipe and Fittings.

T. ASTM B88 - Seamless Copper Water Tube.

U. ASTM B306 - Copper Drainage Tube (DWV).

V. ASTM C14 - Concrete Sewer, Storm Drain, and Culvert Pipe.

W. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings.

X. ASTM C1540 - Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.

Y. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

Z. ASTM D1785 - Polyvinylchloride (PVC) Plastic Pipe, Schedules 40, 80 and 120.

AA. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

BB. ASTM D2661 - ABS DWV Pipe & Fittings.

CC. ASTM D2665 - PVC DWV Pipe & Fittings.

DD. ASTM D2846 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems

EE. ASTM D3033 - Type PSP (Polyvinylchloride) (PVC) Sewer Pipe and Fittings.

FF. ASTM D3034 - Type PSM (Polyvinylchloride) (PVC) Sewer Pipe and Fittings.

GG. ASTM F402 - Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.

HH. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

II. ASTM F439 - Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

JJ. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipes.

KK. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

LL. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings

MM. AWS A5.8 - Brazed Filler Metal.

NN. AWWA C651 - Disinfecting Water Mains.

OO. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems.

PP. CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems.

QQ. FM 1680 - Couplings Used in Hubless Cast Iron Systems.

RR. NSF - National Sanitation Foundation

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

1.6 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 15010 for required plumbing systems electronic CAD drawings to be provided to Coordinating Subcontractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 COLD WATER - POTABLE AND NON-POTABLE
HOT WATER - POTABLE AND NON-POTABLE

A. Design Pressure: 175 psi.
Maximum Design Temperature: 200°F.

B. Piping - All Sizes:

1. Tubing: Type L hard drawn seamless copper tube, ASTM B88.

2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.

3. Fittings: Wrought copper solder joint, ANSI B16.22.

C. Shutoff Valves:

1. Ball Valves:

a. BA-1:

1) 3" and under, 150 psi saturated steam, 600 psi CWP, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-255-FB-P-UL BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

a) Provide extended shaft for all valves in insulated piping.

b) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

D. Check Valves:

1. CK-1: 2" and under, 125# steam @ 406ºF, 200# CWP @ 150ºF, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319-Y, Walworth #3406, Milwaukee #509, Watts #G-5000, Nibco T-413B.

E. Strainers:

1. ST-1: Bronze body, screwed ends, screwed cover, 150 psi S @ 350°F, 200 psi CWP @ 150°F. Armstrong #F4SC, Metraflex #TS, Mueller Steam Specialty Co. #351, Sarco #BT, Watts #777.

2.2 SERVICE WATER - POTABLE

A. Design Pressure: 200 psi.
Maximum Design Temperature: 150ºF.

B. Piping:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4.

2. Fittings: Ductile iron, ANSI/AWWA C110/A21.10, or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, mechanical joints.

3. Joint: Mechanical joint with glands and gaskets and steel bolts. ANSI/AWWAC111/A21.11.

C. Shutoff Valves:

1. Gate Valves:

a. GA-2: 2-1/2" thru 12", 125 psi S @ 353°F, 200 psi CWP @ 150°F, flanged, iron body, bronze mounted, OS&Y. Crane #465-1/2, Hammond, Stockham #G623, Walworth, Milwaukee #F2885, Watts #F-503, Nibco F-617-0.

2.3 SANITARY DRAINAGE (ABOVE GROUND)
SANITARY INDIRECT DRAINAGE (ABOVE GROUND)
SANITARY VENT (ABOVE GROUND)
STORM DRAINAGE (ABOVE GROUND)
CONDENSATE DRAINAGE (ABOVE GROUND)

A. Design Pressure: Gravity
Maximum Design Temperature: 180ºF

B. Piping - All Sizes:

1. Pipe and Fittings: Standard weight cast iron soil pipe, corrosion protective coating inside and outside, ASTM A74, NSF Certified, CISPI Trademark.

2. Joints: Compression gasket, ASTM C564 or lead and oakum, ASTM B29.

3. Adapters: Transitions from cast iron soil pipe to other pipe materials with manufactured adapters. Heavy duty neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with not less than four screw type clamps, FM 1680 or ASTM C1540.

C. Piping - 1-1/4" through 4" (Subcontractor’s Option):

1. Pipe: Type DWV hard temper seamless copper drainage tube, ASTM B306.

2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.

3. Fittings: Cast brass solder joint drainage type, ANSI B16.23 or wrought copper solder joint drainage type, ANSI B16.29.

D. Piping - 1-1/4” through 16” (Maximum Design Temperature: 140°F)(Subcontractor’s Option):

1. Pipe: Schedule 40 rigid, unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with plain ends, conforming to ASTM Standards D2665 or D2661. Cellular core piping is not acceptable.

2. Joints: Solvent-weld socket type with solvent recommended by pipe manufacturer.

3. Fittings: Unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with solvent-weld socket type ends for Schedule 40 pipe.

4. Limits: Schedule 40 PVC-DWV, or ABS-DWV pipe must not be threaded. Do not use where exposed or in return air plenums.

5. Use: Use PVC or ABS only where allowed by local jurisdiction. Comply with all special requirements or limitations.

E. Vent Flashing: Flash vents with premolded EPDM pipe flashing cones for single-ply membrane roofs.

2.4 SANITARY DRAINAGE (BELOW GROUND - INSIDE BUILDING)
SANITARY VENT (BELOW GROUND - INSIDE BUILDING)

A. Design Pressure: Gravity
Maximum Design Temperature: 180ºF

B. Piping - All Sizes:

1. Pipe and Fittings: Standard weight cast iron soil pipe, corrosion protective coating inside and outside, ASTM A74, NSF certified, CISPI trademark.

2. Joints: Compression gasket, ASTM C564.

3. Adapters: Transitions from cast iron soil pipe to other pipe materials with manufactured adapters. Heavy duty neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with not less than four screw type clamps, FM 1680 or ASTM C1540.

2.5 SANITARY DRAINAGE (BELOW GROUND - OUTSIDE OF BUILDING)
STORM DRAINAGE (BELOW GROUND - OUTSIDE OF BUILDING)

A. Design Pressure: Gravity
Maximum Design Temperature: 160ºF

B. Piping - All Sizes:

1. Pipe and Fittings: Standard weight cast iron soil pipe, corrosion protective coating inside and outside, ASTM A74, NSF Certified, CISPI Trademark.

2. Joints: Compression gasket, ASTM C564.

3. Adapters: Transitions from cast iron soil pipe to other pipe materials with manufactured adapters. Heavy duty neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with not less than four screw type clamps, FM 1680 or ASTM C1540.

2.6 STORM - PUMPED (BELOW GROUND)

A. Piping - All Sizes:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4.

2. Fittings: Ductile iron, ANSI/AWWA C110/A21.10, or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, long radius, push-on joints.

3. Joint: Push-on joint with rubber gasket, ANSI/AWWA C111/A21.11.

B. Piping:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4.

2. Fittings: Ductile iron, ANSI/AWWA C110/A21.10, or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar line per ANSI/AWWA C104/A21.4, long radius, mechanical joints.

3. Joint: Mechanical joint with glands and gaskets and steel bolts, ANSI/AWWA C111/A21.11.

2.7 STORM - PUMPED (ABOVE GROUND)

A. Piping - 4" and Under:

1. Pipe: Standard weight galvanized steel, threaded and coupled, ASTM A53.

2. Joints: Screwed.

3. Fittings: Galvanized cast iron screwed drainage type, ANSI B16.12, long radius.

B. Shutoff Valves:

1. Ball Valves:

a. BA-1: 3" and under, 150 psi saturated steam, 600 psi CWP, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze or brass body, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

1) Provide extended shaft for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

2. Gate Valves:

a. GA-7: 2-1/2" thru 12", 200# CWP @ 150ºF, flanged, iron body, bronze trim, OS&Y. Crane #475-1/2, Hammond #IR1146, Stockham #G624, Walworth #8727F, Milwaukee #F2891, Nibco F-617-0.

2.8 CONDENSATE DRAINAGE

A. Design Pressure: Gravity

B. Piping: Same as specified for Sanitary Drainage (Above Ground).

2.9 FOOTING TILE

A. Schedule 40 Perforated PVC Footing Tile - ASTM D1785/76 or DWV Perforated Footing Tile - ASTM D2665/76.

B. Geotextile Fabric: As recommended by the manufacturer for this application. Acceptable Manufacturers: Typar, Cerex, Big 'O'.

2.10 UNIONS

A. Copper pipe - wrought copper fitting - ground joint.

B. Black Steel (Schedule 40) Pipe - malleable iron, ground joint, 150 psi, bronze to bronze seat.

C. Galvanized Steel Pipe - galvanized malleable iron, ground joint, 150 psi, bronze to bronze seat.

2.11 AIR VENTS

A. Provide means for venting air at all high points in the piping system and at all other points where air may be trapped.

B. At end of main and other points where large volume of air may be trapped - Use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

2.12 STRAINERS

A. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows:

Pipe Size	1/4" - 2"
water	3/64"

B. Furnish pipe nipple with shutoff valve to blow down all strainer screens.

C. Use bronze body strainers in copper piping and iron body strainers in ferrous piping.

2.13 DRAIN VALVES

A. Drain valves shall be shutoff valves as specified for the intended service with added 3/4” male hose thread outlet and cap.

2.14 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron, steel, and stainless steel connected to each other.

2. Brass, copper, and bronze connected to each other.

3. Brass or bronze valves and specialties connected to steel, iron, or stainless steel in closed systems. Where two brass or bronze items occur together, they shall be connected with brass nipples.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.

2. Acceptable Manufacturers: Elster Group ClearFlow fittings, Victaulic Series 47, Grinnell Series 407, Matco-Norca.

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.

2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.

3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.

4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.

5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.

6. Acceptable Manufacturers: EPCO, Central Plastics, Pipeline Seal and Insulator, F. H. Maloney, or Calpico.

2.15 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn shutoff valves opening to atmosphere and installed in domestic water piping over 120°F, and as indicated on the drawings.

2.16 VALVE OPERATORS

A. Provide handwheels for gate valves and gear operators for butterfly valves.

2.17 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe unless noted otherwise.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install all products per manufacturer’s recommendations.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

C. Remove scale and dirt, on inside and outside, before assembly.

D. Connect to equipment with flanges or unions.

E. Use only piping materials rated for the maximum temperature of the application, e.g., do not use PVC for dishwasher drainage or piping that receives boiler blowdown.

3.2 TESTING PIPING

A. Sanitary Drainage:
Sanitary Vent:
Storm Drainage:

1. Test all piping with water to prove tight.

2. Test piping before insulation is applied.

3. Hydrostatically test all soil, waste, and vent piping inside of building with 10 feet head of water for 15 minutes. Inspect before fixtures are connected. If leaks appear, repair them and repeat the test.

4. A smoke/air test at the same pressure may be used in lieu of the hydrostatic water test. Exception: Smoke/air test shall not be performed on plastic piping.

5. Test force mains with water at 105% of the operating pump discharge pressure for 15 minutes.

6. Test pressures stated above shall be as listed or as required by the Authority Having Jurisdiction, whichever is most stringent.

B. Hot Water - Potable and Non-Potable:
Cold Water - Potable and Non-Potable:
Service Water:

1. Test pipes underground or in chases and walls before piping is concealed.

2. Test all pipes before the insulation is applied. If insulation is applied before the pipe is tested and a leak develops which ruins the insulation, replace damaged insulation.

3. Test the pipe with 100 psig water pressure or equal inert gas such as nitrogen.

4. Hold test pressure for at least 2 hours.

5. Test to be witnessed by Fermilab's representative, if requested by Fermilab.

C. Fire Service:

1. Hydrostatically test the entire system for two hours at 200 psig. Maximum leakage shall be:

   a. Interior Piping: 0 quarts per hour.

   b. Underground Piping: 2 quarts per 100 joints per hour.

3.3 CLEANING PIPING

A. Assembly:

1. Before assembling pipe systems, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of Fermilab's representative. Blow chips and burrs from machinery or thread cutting operation out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing.

3. Notify Fermilab's representative before starting any post erection cleaning in sufficient time to allow witnessing the operation. Consult with and obtain approval from Fermilab's representative with regard to specific procedures and scheduling. Dispose of cleaning and flushing fluids properly.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

B. All Water Piping:

1. Flush all piping using faucets, flush valves, etc. until the flow is clean.

2. After flushing, thoroughly clean all inlet strainers, aerators, and other such devices.

3. If necessary, remove valves to clean out all foreign material.

C. Fire Service:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

   a. 390 gpm for 4" pipes.
   b. 880 gpm for 6" pipes.

3.4 INSTALLATION

A. General Installation Requirements:

1. Provide dielectric connections between dissimilar metals.

2. Route piping in orderly manner and maintain gradient. Install to conserve building space.

3. Group piping whenever practical at common elevations.

4. Install piping to allow for expansion and contraction without stressing pipe, joints, or equipment.

5. Slope water piping and arrange to drain at low points.

6. Install bell and spigot piping with bells upstream.

7. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

8. Seal pipes passing through exterior walls with a wall seal per Section 15140. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

9. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8” high lettering saying “Non-Potable Water Not for Human Consumption.” Sign shall have black lettering on a yellow background.

10. All vertical pipe drops to sinks or other equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted.

B. Installation Requirements in Electrical Equipment Areas:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Install shutoff valves that permit the isolation of equipment/fixtures in each room without isolating any other room or portion of the building. Individual fixture angle stops do not meet this requirement. Exception: Back-to-back rooms in no more than two adjacent rooms.

2. Provide clearance for installation of insulation and access to valves and fittings.

3. Provide access doors for concealed valves and fittings.

4. Install valve stems upright or horizontal, not inverted.

5. Provide one plug valve wrench for every ten plug valves 2" and smaller, minimum of one. Provide each plug valve 2-1/2" and larger with a wrench with set screw.

D. Underground Piping:

1. Install buried water piping outside the building with at least 5 feet of cover.

2. Underground fire protection service piping shall have at least 6-1/2 feet of cover, or as recommended by NFPA 24, whichever is greater.

3. Install thrust blocking and restraints on all underground fire protection service piping per NFPA 24 and as shown on drawings.

4. Install underground, sleeved, corrugated, stainless steel tubing system according to manufacturer's written instructions. Extend vent from sleeve to exterior of building and terminate with screened elbow.

5. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.

6. For all underground piping, provide a foundation (the layer below the bedding) if the trench bottom is unstable. Lay underground plastic piping on 4" to 6" of sand bedding. When the trench is in rock, lay underground metallic piping on 6" of sand bedding. Provide recessed areas for pipe bells and joints. After joints are made, any misalignment in elevation shall be corrected by tamping sand around the pipe. Backfill with sand in uniform layers not over 6" deep to the spring line of all underground pipes, and carefully compact each layer to 90 percent Standard Proctor density. Backfill with sand up to 6" above pipe for landscaped areas. Remaining backfill may be soil. Under paving and buildings, the remaining backfill shall be sand and compacted to 98 percent Standard Proctor density.

7. As an option, the Subcontractor may provide factory applied protective coatings consisting of a polyethylene plastic film bonded to the pipe surface by a hot applied thermo-plastic adhesive.

   a. Acceptable Manufacturer: Republic Steel Corp. "X-Tru-Coat"

8. Exercise care in handling, storing and laying pipe to avoid damaging factory applied coatings. If any damage occurs, repair the coating to a condition equal to the original.

9. Field application of protective coatings to joints, fittings and to any damaged factory applied coatings shall be similar to factory applied coatings specified above and shall be done in strict accordance with recommendations of the supplier of pipe coatings.

10. After completion of the fabrication, laying and field coating of the joints and fittings, but prior to backfilling, inspect the entire line in the presence of Fermilab's representative with an electronic holiday detector. Any defects in the protective coatings shall be repaired in accordance with requirements for original coatings.

11. Coat flange bolts and nuts in pits and below ground at the time of installation with a corrosion protective coating.

E. Sanitary and Storm Piping:

1. Install all sanitary piping inside the building with a slope of at least the following:

Pipe Size	Minimum Slope
3" and under	- 0.25" per foot
4" and over	- 0.125" per foot

2. Slope sanitary and storm piping outside the building to meet the invert elevations shown on the drawings and to maintain a minimum velocity of 3 feet per second.

3. All sanitary and storm piping shall have at least 42" of cover when leaving the building.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings, or nameplates with sufficient data to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not install any item that is not clean.

D. Until system is fully operational, all openings in piping and equipment shall be kept closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

E. Run pipes straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required to provide needed headroom or clearance and to provide needed flexibility in pipe lines.

F. Make changes in direction of pipes only with fittings or pipe bends. Changes in size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be of the long radius type, unless otherwise shown on the drawings or specified.

G. Provide flanges or unions at all final connections to equipment, traps and valves.

H. Arrange piping and connections so equipment served may be totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or equipment.

K. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

L. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Provide and operate sufficient pumping equipment to maintain excavations, trenches and pits free of water. Dispose of pumped water so operation areas and other facilities are not flooded. Pipe laying shall follow excavating as closely as possible.

M. Unless otherwise indicated, branch take-offs shall be from top of mains or headers at either a 45º or 90º angle from the horizontal plane for air lines, and from top, bottom or side for liquids.

N. Do not use geotextile fabric with footing tile if silt content of soil exceeds 40% or if clay content exceeds 50%. The fabric shall be installed around 1" river rock or 2” limestone.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal water lines, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate and venting.

B. Maintain accurate grade where pipes pitch or slope for venting and drainage. No pipes shall have pockets due to changes in elevation.

C. Provide drain valves at all low points of water piping systems for complete or sectionalized draining.

D. Use eccentric reducing fittings on horizontal runs when changing size of pipes for proper drainage and venting. Install compressed air and gravity drain pipes with bottom of pipe and eccentric reducers in a continuous line; all other liquid lines with top of pipe and eccentric reducers in a continuous line.

E. Provide air vents at high points and wherever else required to eliminate air in all water piping systems.

F. Install air vents in accessible locations. If necessary to trap and vent air in a remote location, install an 1/8" pipe from the tapping location to an accessible location and terminate with a venting device.

G. All vent and drain piping shall be of same materials and construction for the service involved.

3.7 PLUMBING VENTS

A. Vent as shown on the drawings and in accordance with all codes having jurisdiction.

B. Extend the high side of the soil and waste stacks at least 12" above roof.

C. Flash pipes at roof with premolded EPDM pipe flashing cones adhered to roof membrane by General Subcontractor. Secure top of cone with stainless steel clamp and seal watertight.

D. Increase vent pipes through the roof two pipe sizes with long increasers located at least 12" below the roof.

E. In no case shall the vent through the roof be less than 4" in diameter.

F. Vent pipes through the roof shall be located a minimum of 15 feet from any air intake or exhaust opening on the roof.

3.8 BRANCH CONNECTIONS

A. For domestic water and vent systems only, make branch connections with standard tee or cross fittings of the type required for the service.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Do not use double wye or double combination wye and eighth bend DWV fittings in horizontal piping.

D. Branch connections from the headers and mains may be mechanically formed using an extraction device. The branch piping connection shall be brazed connection for the following services only:

1. Domestic water piping above grade.

E. Further limit use of mechanically formed fittings as follows:

1. Must have at least same pressure rating as the main.
2. Main must be type K or L copper tubing.
3. Permanent marking shall indicate insertion depth and orientation.
4. Branch pipe shall conform to the inner curve of the piping main.
5. Main must be 1" or larger.
6. Branch must be 3/4" or larger.

F. Branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

G. Forged weld-on fittings are limited as follows:

1. Must have at least same pressure rating as the main.
2. Main must be 2-1/2" or larger.
3. Branch line is at least two pipe sizes under main size.

3.9 JOINING OF PIPE

A. Threaded Joints:

1. Threads shall conform to ANSI B2.1 "Pipe Threads".

2. Ream pipe ends and remove all burrs and chips formed in cutting and threading.

3. Protect plated pipe and valve bodies from wrench marks when making up joints.

4. Apply thread lubricant to male threads as follows:

Vents and Roof Conductors:	Red graphite
All Other Services:	Teflon tape

B. Solder Joints:

1. Make up joints with 100% lead-free solder, ASTM B32. Cut tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly so solder will flow to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.

2. Flux shall be non-acid type.

3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470ºF melting point solder. Remove discs and seals during soldering if they are not suitable for 470ºF.

C. Brazed Joints:

1. Make up joints with silver alloy brazing filler metal conforming to ASTM B260 "Brazing Filler Metal" BAg-1 or BAg-2. Cut copper tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to brazing. Apply non-corrosive flux of the type recommended by filler alloy manufacturer, evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly using oxygen-acetylene torch with tip size recommended by fitting manufacturer. Wipe and brush joint clean after alloy has set.

2. Remove discs from solder end valves during brazing.

D. Welded Joints:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless mandatory local codes take precedence.

2. Furnish to Fermilab's Representative prior to start of work certificates qualifying each welder.

3. Fermilab's Representative reserves the right to require qualifying demonstration, at the Subcontractor's expense, of any welders assigned to the job.

4. Ends of pipe and fittings to be joined by butt welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

5. Backing rings shall be used for all butt weld joints 3" size and over, and for all sizes where operating pressure is over 200 psig and/or temperature is over 400ºF. Backing rings shall be of the material being welded.

E. Mechanical Joints:

1. Joints shall conform to ANSI A21.11 "Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings". Gasket material shall be neoprene. The standard bolts and nuts of the pipe manufacturer shall be used and shall be coated at the factory with rust preventive lubricant after threading and tapping.

2. Final tightening of bolts shall be with a torque wrench to insure equal tension in all bolts.

F. Compression Gasket Joints - Sanitary Pipe and Storm Pipe:

1. Joint shall be one piece double seal compression type gasket made specifically for joining cast iron soil pipe. Gasket shall be neoprene, permitting joint to flex as much as 5 degrees without loss of seal. Gasket shall be extra heavy weight class, conforming to ASTM C-564.

G. Lead and Oakum Joints - Sanitary Pipe and Storm Pipe:

1. Pack joint with oakum made of vegetable fiber, cotton, or hemp. Pour joint with molten lead up to top of hub. Ensure leak-free joints by working joint with inside and outside caulking irons.

H. Solvent Weld Joints (PVC):

1. Make joints with a two-step process. Use primer conforming to ASTM F656 and solvent cement conforming to ASTM D2564.

I. Solvent Weld Joints (CPVC):

1. Make joints with a one-step process. Use CPVC cement conforming to ASTM F493. A primer is not required.

2. If a primer is required by the Authority Having Jurisdiction, then a primer conforming to ASTM F656 shall be used.

J. Fusion Weld:

1. Make all field cuts of pipe square and true using a pipe cutter designed for plastic pipe.

2. Make sure proper heating heads are used for male and female situations.

3. Bevel the leading edge of pipe section with a 45° chamfer.

4. Utilize a fusion welding tool recommended and/or provided by the pipe and fitting manufacturer.

5. Not recommended for temperatures below 40°F.

6. Follow the manufacturer's cold weather installation procedures.

7. All installers shall undergo training provided by the manufacturer or manufacturer's representative.

8. Follow all manufacturer’s installation instructions.

K. Elastomeric Gaskets (Sanitary and Storm Pipe):

1. Hub and spigot pipe joints with elastomeric gaskets shall be made in accordance with the manufacturer's installation instructions.

L. Sleeve Gaskets (No-Hub) (Sanitary and Storm Pipe):

1. Gasket shall be heavy weight class, conforming to ASTM C564.

2. The gasket shall have an internal center stop.

3. The gasket shall be covered by a stainless steel band secured with a minimum of four stainless steel bands per fitting/joint.

4. Sleeve gaskets shall be installed in accordance with the manufacturer’s installation instructions.

3.10 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Provide necessary connections at the start of individual sections of mains for adding chlorine.

B. Before starting work, verify system is complete, flushed and clean.

C. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).

D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

E. Bleed water from outlets to ensure distribution and test residual at minimum 15% of outlets.

F. Maintain disinfectant in system for 24 hours.

G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.

H. Flush disinfectant from system until residual is equal to that of incoming water or 1.0 mg/L.

I. Take samples no sooner than 24 hours after flushing, from 2% of outlets and from water entry, and analyze in accordance with AWWA C651.

3.11 SERVICE CONNECTIONS

A. Provide new sanitary services. Before commencing work check invert elevations needed for sewer connections, confirm inverts and verify these can be properly connected with slope for drainage and cover to avoid freezing.

B. Provide new water service with water meter. Provide sleeve in wall for service main per Section 15140.

END OF SECTION 15410

SECTION 15430 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Floor Drains.
B. Cleanouts.
C. Traps.
D. Trap Seals.
E. Water Hammer Arresters and Air Chambers.

1.2 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.3 REFERENCES

A. ANSI A112.21.1 - Floor Drains.

B. ASSE 1010 - Water Hammer Arresters.

C. ASSE 1047 - Reduced Pressure Detector Assemblies.

D. PDI WH-201 - Water Hammer Arresters.

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Section 15010.

B. Include sizes, rough-in requirements, service sizes, and finishes.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Provide cleanouts as shown and specified on the drawings as well as required by code.

B. Coordinate floor cleanout cover with surrounding floor finish. Provide either solid, recessed for tile or terrazzo as applicable.

C. Cleanouts on exposed pipes shall be cast iron with heavy duty cast brass plug with raised head.

D. Cleanout shall be same size as the pipe up to 6" and 6" for larger pipes.

2.2 YARD CLEANOUTS

A. Provide yard cleanouts as shown and specified on the drawings as well as required by code.

B. Cleanout shall be same size as pipe up to 6" and 6" for larger pipes.

2.3 TRAPS

A. Provide all individual connections to the sanitary system with P-traps, except where such drains discharge directly into a properly trapped collection basin or sump. Unless otherwise specified or shown, traps shall be:

1. Chromium plated cast brass when used with plumbing fixtures or when installed exposed in finished spaces.

2. Insulated at accessible lavatories.

3. Cast iron, deep-seal pattern where concealed above ceiling, below grade or in unfinished areas.

4. Deep-seal pattern of the same material and/or coating where drainage lines are of special materials or coatings such as polypropylene, PVDF, CPVC, etc.

B. All traps shall have accessible, removable cleanouts, except where installed on floor drains with removable strainers.

C. Each trap shall be completely filled with water at the end of construction but before building space turnover to Fermilab. All floor drains, floor sinks, trench drains, etc. shall be filled with water and a 1/2” minimum layer of mineral oil.

2.4 TRAP SEALS

A. Provide trap seals as specified on the drawings.

2.5 FLOOR DRAINS

A. Provide floor drains and sinks as shown and specified on the drawings as well as required by code.

2.6 WATER HAMMER ARRESTERS AND AIR CHAMBERS

A. Provide water hammer arresters as shown and specified on the drawings as well as required by code.

B. ANSI A112.26.1; sized and located in accordance with PDI WH-201, precharged for operation between -100ºF and 300ºF and maximum 250 psig working pressure.

C. Air chambers shall meet the requirements of the applicable plumbing code. Minimum 12” long at fixtures and minimum 24” long on risers. Air chambers shall be the same size or larger than the piping it is connected to.

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. Coordinate construction to receive drains at required invert elevations.

B. Install all items per manufacturer's instructions.

C. Water Hammer Arresters and Air Chambers:

1. Install water hammer arresters in accessible locations. Provide access doors as required. Coordinate type with Fermilab/Fermilab.

2. Water hammer arrestors shall be installed in cold and hot water lines upstream of all plumbing fixtures or equipment, with a quick acting valve or multiple quick acting valves. Quick acting valves shall be defined as solenoid actuated valves, manual flush valves, sensor activated faucets and flush valves, squeeze handle spray faucets, and other similar type valves.

3. Install multiple water hammer arrestors in toilet group branch piping greater than 20 feet in developed length from the cold and hot water mains.

4. Install air chambers at each fixture not protected by a water hammer arrester.

D. Cleanouts:

1. Provide cleanouts where shown on the drawings and as required by code, but in no case farther apart than 50 feet in pipe less than 6" size and 100 feet apart in 6” and larger pipes inside the building.

2. Provide cleanouts at bases of all sanitary and storm risers as shown on the drawings and as required by code.

3. Extend cleanouts to the floor with long sweep elbows.

4. Install a full size, two-way cleanout within 5 feet of the foundation inside or outside of building.

5. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with graphite and linseed oil. Ensure clearance at cleanouts for rodding of drainage system.

6. Wall cleanouts shall be installed above the flow line of the pipe they serve, but no less than 12” above the finished floor.

E. Yard Cleanouts:

1. Install cleanouts on maximum 90 foot centers (including riser) for pipes 8" and smaller.

2. Extend cleanout to grade. Encase cleanout in 5" thick concrete pad extending 6" beyond cleanout, set low enough not to interfere with lawn mowers.

F. Trap Seals:

1. Install trap guard on drains not receiving continuous discharge and subject to drying out.

G. Floor Drains:

1. Drains in upper floors shall have a flashing of EPDM or similar membrane sheet. The sheet shall be at least 36" X 36" square with the drain in the center. Clamp membrane in auxiliary clamping ring of floor drain. Membrane is not required if upper floor construction is single pour, cast-in-place concrete.

2. Coordinate sloping requirements with the architectural plans and specifications.

END OF SECTION 15430

SECTION 15440 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All plumbing fixtures.

1.2 REFERENCES

A. ANSI A112.6.1M - Supports for Off-the-Floor Plumbing Fixtures for Public Use.

B. ANSI A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.

C. ANSI A112.19.2M - Vitreous China Plumbing Fixtures.

D. ANSI A112.19.5 - Trim for Water-Closet Bowls, Tanks, and Urinals.

E. ASSE 1002 - Water Closet Flush Tank Ball Cocks.

F. Americans with Disabilities Act (ADA), Title III.

G. The Energy Policy Act (EPAct) of 2005.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 15010. Submittals shall include fixture carriers for record purposes only. Fermilab does not review or approve carriers except for manufacturer.

B. Include fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wall Hung Fixture Carriers:

1. Material: All Metal, ASME/ANSI A112.6.1M.

2. Acceptable Manufacturers: Zurn, Smith, Wade, Josam, Watts, Mifab.

3. Water closet carrier shall be rated to support 500 lbs. unless noted otherwise on the drawings.

B. All fixtures shall be as scheduled on the drawings.

C. All china shall be from the same manufacturer where possible.

D. All lavatory and sink trim shall be from the same manufacturer where possible.

E. All fixtures shall be lead free. Faucets, traps, stops, and other fixture accessories shall not contain more lead than allowed per the latest State or Federal Act.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install each fixture with trap easily removable for servicing and cleaning. Use screwed tailpiece couplings. Connect fixture waste to stack with slip fitting.

2. Provide fixtures with chrome plated rigid or flexible supplies, loose key stops, reducers, and escutcheons.

3. Install components level and plumb.

4. Caulk joint between finish floor and floor mounted fixtures and between finish walls and wall mounted fixtures with silicon caulk. Caulk the joint, between rim and fixture where a fixture builds into a counter top, with caulking compound. Refer to DIVISION 7 for "Caulking" requirements. Color to match fixture.

5. Where there is a possibility of water following pipe brackets, etc., into a wall; caulk escutcheons, space around brackets, etc., to exclude water. Refer to DIVISION 7 for "Caulking" requirements.

6. Refer to Plumbing Material List for fixture mounting heights.

7. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8” high lettering saying “Non-Potable Water Not for Human Consumption.” Sign shall have black lettering on a yellow background.

B. Wall-Mounted Fixture Requirements:

1. All wall-mounted fixtures shall have compatible carriers designed for their intended service and suitable for the space available and configuration of fixtures. All carriers shall extend to the floor and be anchored to the slab.

C. Exposed or Inside Accessible Cabinets Traps, Valve and Pipe Requirements:

1. All traps exposed under fixtures or inside accessible cabinets shall be chrome plated brass.

2. All water or waste piping for plumbing fixtures that is exposed or inside cabinets shall be chrome plated.

3. All exposed flush valves for water closets and urinals shall have a chrome plated hanger to anchor the piping to the wall.

4. All exposed water supply piping and fittings in a finished space to a shower valve, hose bibb, or other water outlet shall be chrome plated.

D. ADA Lavatory Requirements:

1. All handicapped accessible lavatory traps, piping and angle stops shall be installed with an insulating kit specially manufactured for this installation. Armaflex with duct tape is not acceptable.

E. ADA Water Closet Requirements:

1. Handicapped accessible water closet flush valve handles shall face the center of the stall.

2. Coordinate flush valves in handicap accessible locations with grab bars installed by the General Subcontractor. Make modifications required to flush valve after review by Fermilab.

3.2 ADJUSTING AND CLEANING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. At completion, clean plumbing fixtures, equipment, and faucet aerator screens.

3.3 FIXTURE ROUGH-IN SCHEDULE

A. Rough-in fixture piping connections in accordance with table on plumbing drawings of minimum sizes for particular fixtures.

END OF SECTION 15440

SECTION 15515 - NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Natural Gas Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

1.3 REFERENCES

A. ANSI/AWS D1.1 - Structural Welding Code.

B. ANSI AGA-LC1 - Standards for Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing.

C. ANSI/AWWA C111/A21.11 - Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.

D. ASME - Boiler and Pressure Vessel Code - Section 9.

E. ASME B1.20.1 - Pipe Threads, General Purpose.

F. ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.

G. ASME B16.5 - Pipe Flanges and Flanged Fittings.

H. ASME B16.9 - Factory-Made Wrought Steel Butt Welding Fittings.

I. ASME B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.

J. ASME B16.21 - Nonmetallic Flat Gaskets for Pipes Flanges.

K. ASME B16.39 - Malleable Iron Threaded Pipe Unions.

L. ASME B18.2.1 - Square and Hex Bolts and Screws, Inch Series.

M. ASME B18.2.2 - Square and Hex Nuts, Inch Series.

N. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

O. ASTM A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.

P. ASTM A181 - Forgings, Carbon Steel for General Purpose Piping.

Q. ASTM A197 - Standard Specification for Cupola Malleable Iron.

R. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

S. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

T. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

U. ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing and Fittings.

V. ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe.

W. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.

X. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

Y. NFPA 54 - National Fuel Gas Code.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.1 NATURAL GAS (0 TO 125 PSI)

A. Design Pressure: 125 psi.
Maximum Design Temperature: 350ºF

B. Piping - 2" and Under:

1. Pipe: Standard weight steel, threaded and coupled, ASTM A53.

2. Joints: Screwed.

3. Fittings: 150# steam - 300# CWP, black malleable iron, banded, ASTM A197, ANSI B16.3.

4. Unions: 250# - 500# CWP, black malleable iron, ANSI B16.39, ground joint with brass seat.

C. Shutoff Valves/Throttling Valves:

1. BA-13: 2” and under, threaded 600 psi CWP; UL listed for 250# LP, flammable liquid, heating oil, natural and manufactured gases, 150 psi steam, bronze body and chrome plated brass ball, Teflon seats and packing. Apollo #80-100, Nibco #T580-70-UL or #T585-70-UL, Watts #B-6000.

2. PL-1: 2" and under, 125# steam @ 450ºF, 175# CWP @ 180ºF, cast iron body, screwed, full port. Walworth #1700, DeZurik #425, S-RS49.

D. Check Valves:

1. CK-1: 2" and under, 125# steam @ 406ºF, 200# CWP @ 150ºF, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319-Y, Walworth #3406, Milwaukee #509, Watts #B-5000, Nibco Y-413B.

2. CK-13: 2-1/2" thru 12", 200# CWP, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size. Mueller Steam Specialty Co. #71-AHB-6-H, Stockham #WG-961 EPDM or #WG970 BUNA, NIBCO W-920-W, Crane.

2.2 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4” male hose thread outlet, cap, and retaining chain.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends, remove burrs, bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Connect to all equipment with flanges or unions.

D. After completion, fill, clean, and treat systems. Refer to Section 15545 for treatment.

3.2 TESTING PIPING

A. Low Pressure - Up to 1 psi:

1. Test piping with 20 psi air pressure. System must hold this pressure without adding air for two hours.

B. High Pressure - Above 1 psi:

1. Test piping with compressed air at twice the operating gas pressure, but at least 20 psi. System must hold this pressure without adding air for two hours.

C. A non-combustible odorant, such as oil of wintergreen, may be added to help locate leaks.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of Fermilab. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.

3. Notify Fermilab prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

3.4 INSTALLATION

A. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

B. Install piping to conserve building space, and not interfere with other work.

C. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance for access to valves and fittings.

G. Prepare pipe, fittings, supports, and accessories for finish painting.

H. Install valves with stems upright or horizontal, not inverted.

I. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.

J. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

K. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

L. Provide flanges or unions at all final connections to equipment, traps and valves.

M. Each above ground portion of a gas piping system that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance.

N. Gas piping shall not be used as a grounding conductor or electrode.

O. Where a lightning protection system is installed, the bonding of the gas piping shall be in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. **All fittings shall be long radius type**, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Cut all pipe to exact measurement and install without springing or forcing.

H. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage.

B. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install gas pipes with bottom of pipe and eccentric reducers in a continuous line.

C. Provide drip legs at low points and at the base of all risers in gas pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Subcontractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

D. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

E. All branch piping connections for natural gas shall take off on the top or on the side of the main.

3.8 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

3.9 SERVICE CONNECTIONS

A. Provide new gas service complete with gas meter and regulators. Verify gas service pressure with Fermilab.

END OF SECTION 15515

SECTION 15780 - PACKAGED ROOFTOP AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Rooftop Unit.
B. Unit Controls.
C. Remote Panel.
D. Roof Mounting Frame and Base.

1.2 QUALITY ASSURANCE

A. All insulation inside the unit and in the air stream must comply with the requirement of NFPA 90A (maximum flame spread of 25 and maximum smoke developed of 50).

B. All units must be UL or ETL listed and must contain UL labeled components.

C. Fans shall be tested and rated in cabinet in accordance with AMCA Standard 210. All fan assemblies shall be dynamically balanced in cabinet at final assembly.

D. Conform to ASHRAE 90.1.

E. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. ARI 210 - Unitary Air Conditioning Equipment.

B. ARI 240 - Air Source Unitary Heat Pump Equipment.

C. ARI 270 - Sound Rating of Outdoor Unitary Equipment.

D. ASHRAE 37 - Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment.

E. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

F. NFPA 70 - National Electrical Code.

G. NFPA 90A - Installation of Air Conditioning and Ventilating System.

H. UL - Underwriters' Laboratory.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 15010.

B. Indicate electrical service and duct connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, installation instructions, maintenance and repair data, and parts listing.

1.7 WARRANTY

A. Provide five (5) year manufacturer’s warranty for compressors.

B. Provide ten (10) year manufacturer’s warranty for heat exchanger.

C. Provide three (3) year manufacturer’s warranty for controls and electrical components (thermostats, VFD, etc.).

1.8 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

1.9 MAINTENANCE SERVICE

A. Furnish complete service and maintenance of packaged roof top units for one year from Date of Substantial Completion.

B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six filter replacements, minimum of one fan belt replacement, and controls check-out, adjustments, and recalibrations.

D. Submit copy of service call work order or report, and include description of work performed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Trane.
B. York.
C. Daikin/McQuay.
D. Carrier.
E. Aaon.

2.2 MANUFACTURED UNITS

A. Provide roof-mounted units having gas burner, and electric refrigeration.

B. Unit shall be self-contained, packaged, factory assembled, pre-wired and tested, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, controls, air filters, refrigerant cooling coil and compressor, condenser coil, condenser fan, and a full refrigerant charge.

C. Unit shall be furnished with non-fused disconnect switch, short fuse protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

2.3 FABRICATION

A. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hinges. Access doors shall be provided at each section (e.g., filter section, supply fan section, etc.). All exterior access panels must be permanently labeled on the outside indicating what is behind the panel. Structural members shall be minimum 18 gauge, with access doors or removable panels of minimum 20 gauge.

B. Outside Air Intakes: The outside air intakes shall be located a minimum of 15 inches above the curb to minimize the effects of snow during winter operation. Each air intake shall be furnished with rain eliminators.

C. Insulation: Minimum of 1/2” thick, 1.5 lb/cu.ft. density coated glass fiber insulation on surfaces where conditioned air is handled. Protect edges from erosion.

D. Heat Exchangers: Stainless steel, of welded construction.

E. Air Filters: 90-95% Cartridge Filter Option, MERV 14 - Twelve-inch deep cartridge filters shall be mounted in a galvanized steel frame. Filters shall be Class 1 listed by Underwriters Laboratories and have a 90-95% dust spot efficiency per ASHRAE 52-76. To ensure maximum cartridge filter life, two-inch MERV 8 pre-filters shall be provided.

F. Curb: Prefabricated roof curb, minimum 14 gauge galvanized steel, with welded corners and with seams joined by continuous water and airtight welds. Curb shall be internally reinforced with angles 48” on center and factory installed wood nailer. Curb shall be internally insulated with 1 1/2” thick 3 lbs. density rigid

insulation. Height to be minimum of 24” above grade. Top of curb shall be level. Supply and return plenums shall be thermally separated and configured for side supply and return duct connections as shown on drawings.

2.4 FANS/MOTORS

A. Supply Fan: Single width airfoil blade plenum type, mounted on a shaft with a fixed sheave drive or direct drive as indicated. Isolate complete fan assembly. All fan bearings must be capable of being lubricated by easily accessible grease fittings.

B. Exhaust Fan: Provide forward curved exhaust fans with fixed-pitch sheave drive assemblies. Dynamically balance all fans and the unit’s running fan assembly (fan mounted on actual shaft, bearings and in scroll housing) to assure smooth operation of the fan and it’s associated assembly.

C. All fans must be statically and dynamically balanced.

D. Motors shall be open drip-proof with grease lubricated bearings.

E. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 15170.

F. Internal Shaft Grounding Ring- Motors have internal bearing protection for use with VFDs to provide a conductive discharge path away from the motor bearings to ground. Bearing Protection Rings are circumferential rings with conductive micro fibers which provide the path of least resistance and dramatically extend motor life.

G. Units used with variable speed drives shall have fixed sheaves. This Subcontractor shall provide replacement sheaves and belts as required to allow final air balancing.

H. No equipment shall be selected or operate above 90% of its motor nameplate rating.

2.5 BURNER

A. Gas Burner: Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shutoff, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shutoff pilot. Single stage fully modulating gas valve with minimum 7:1 turndown.

B. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

C. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

D. Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, or adjustable time delay relays with switch for continuous fan operation.

2.6 EVAPORATOR COIL

A. Provide copper tube with copper fin coil assembly.

B. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft^2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8” per foot.

C. Provide pitched stainless steel drain pan to assure positive drainage of condensate from the unit casing

D. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

2.7 COMPRESSOR

A. Provide hermetic or semi-hermetic compressors (quantity as scheduled on drawings), 3600 rev/min maximum, resiliently mounted with positive lubrication, crankcase heater for operation down to 0°F, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

B. Five minute timed off circuit shall delay compressor start.

C. Outdoor thermostat shall energize compressor above 50ºF ambient.

D. The variable speed compressor shall be capable of speed modulation from 25 Hz to a maximum of 100 Hz. The minimum unit capacity shall be 15% of full load or less. The compressor motor shall be a permanent magnet type. Each compressor shall have a crankcase heater installed, properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles. Compressors shall be equipped with a thrust bearing oil injection system that optimizes scroll set lubrication and controls the oil circulation rate. Optimal bearing lubrication shall be provided by a gear rotor oil pump. Each variable speed compressor shall be matched with a specially designed variable frequency drive which modulates the speed of the compressor motor and provides several compressor protection functions. Control of the variable speed compressor and inverter control shall be integrated with the roof top unit controller to ensure optimal equipment reliability and efficiency. Modulating Hot Gas Reheat- Unit shall consist of the following refrigeration components on one circuit: a hot gas reheat coil, a cooling modulating valve, a reheat modulating valve, a reheat check valve, a reheat pump out solenoid, and additional interconnecting tubing.

E. Provide step capacity control by cycling multi-speed compressors.

F. The use of chlorofluorocarbon (CFC)-based refrigerants is prohibited.

2.8 CONDENSER

A. Provide copper tube aluminum fin coil assembly with sub-cooling rows or Aluminum Microchannel condenser coils. All coils shall be leak tested at the factory to ensure pressure integrity. The condenser coil is pressure tested to 650 psig. Subcooling circuits(s) shall be provided as standard.

B. Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor.

C. Provide refrigerant pressure switches to cycle condenser fans.

D. Provide factory-installed louvered steel coil guards around perimeter of condensing section to protect the condenser coils, refrigerant piping and control components. Louvered panels shall be fabricated from heavy gauge galvanized steel and be rigid enough to provide permanent protection for shipping and pre-/post- installation. Course wire mesh is not an acceptable material for coil guards.

2.9 MIXING SECTION

A. Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper shall fail to closed position.

B. Provide 100% modulating dry bulb temperature based economizer system fully integrated with unit return and exhaust air dampers. Unit operation is through primary temperature controls that automatically modulate dampers to maintain desired space temperature conditions.

C. Provide automatic outdoor dry bulb temperature lockout sensor.

D. Outside Air Measurement - A factory mounted airflow measurement station shall be provided in the outside air opening to measure airflow. The airflow measurement station shall measure from 40 cfm/ton to maximum airflow. The airflow measurement station shall adjust for temperature variations.

E. Gaskets: Provide tight fitting dampers with edge gaskets, maximum leakage 5 percent at 2 inches pressure differential. Gaskets must be mechanically fastened (use of adhesive alone shall not be acceptable).

F. Damper Operator: 24 volt with gear train sealed in oil, with spring return on units 7.5 tons cooling capacity and larger.

2.10 ELECTRICAL

A. Provide with single point power connection, disconnect, transformer, and convenience outlet. All units must be so constructed that when the electrical section access panel is opened, all electrical power to the unit (with the exception

of the 120 volt duplex convenience outlet) is disconnected by means of a single disconnect.

B. All wiring must be labeled, numbered, and terminate in "spade clips". All terminal strips must be keyed to the wiring numbers. Each control device must be permanently labeled to indicate its function.

C. Wiring diagrams for all circuits must be permanently affixed to the inside of the electrical section access panel. The markings of terminal strips and wiring must agree with the numbering on the wiring diagrams.

D. All units shall include a transformer for controls and convenience outlet.

E. Only one power cable connection to the unit shall be necessary.

2.11 DDC TEMPERATURE CONTROLS

A. Install standalone control module providing communication between unit controls and DDC temperature control system. Control module shall be compatible with temperature control system specified in Section 15952.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that installation area and concrete pad are ready to receive work.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory built frame providing watertight enclosure to protect ductwork and utility services. Install mounting frame level.

C. All field wiring shall be in accordance with the National Electrical Code.

D. P-traps must be provided for all drain pans.

E. Comb all coils to repair bent fins.

F. Install on vibration isolation as scheduled on drawings.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation, including routine servicing and check-out.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01810 Commissioning.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01810. Functional performance testing shall be performed by the subcontractor and witnessed and documented by the Commissioning Authority.

END OF SECTION 15780

SECTION 15835 - TERMINAL HEAT TRANSFER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cabinet Heaters.
B. Electric Unit Heaters.

1.2 QUALITY ASSURANCE

A. All filters shall be UL listed Class 1 or Class 2.

B. All electrical equipment shall have a UL label.

C. All louvers and dampers shall have AMCA certified ratings.

D. Factory wired equipment shall conform to ANSI/NFPA 70.

1.3 REFERENCES

A. ANSI/ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010.

B. Submit catalog data including arrangements, cross sections of cabinets, grilles, bracing, typical elevations.

C. Submit schedules of equipment and enclosures indicating length, number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, and comparison of specified to actual heat output.

D. Indicate mechanical and electrical service locations and requirements. Show deviations from scheduled products.

E. Submit manufacturers' installation instructions.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.6 REGULATORY REQUIREMENTS

A. Conform to ASHRAE 90.1.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's operation and maintenance data. Include operating, installation, maintenance and repair data, and parts listings.

1.8 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 ELECTRIC CABINET HEATERS

A. Forced air wall mounted heaters shall include cabinet, fan, motor, coil, inlet grille and discharge grille.

B. Coil: Electric dual element with finned steel sheaths.

C. Blower shall have a two-speed split capacitor motor and a concealed unit mounted "Off-Low-High" fan speed switch.

D. Power connections, circuit breaker, or disconnect shall be provided by the E.C.

E. Units shall have 1" disposable filters ahead of all coils.

F. Cabinets shall have 16 gauge exposed surfaces, 18 gauge concealed surfaces, and no exposed plastic parts.

G. Baked enamel finish. Color selected by Architect.

H. Acceptable Manufacturers: Trane, Berko.

2.2 ARCHITECTURAL ELECTRIC WALL HEATERS

A. Assembly: UL listed and labeled with terminal box and cover, fan guard, and built-in controls. Draw-through design. Provide with baked enamel finished steel back box suitable for wall mounting.

B. Heating Elements: Nickel-chromium resistance wire enclosed in a steel sheath with copper brazed plate fins.

C. Cabinet: Minimum 20 gauge steel with baked enamel finish. Provide surface mount, semi-recessed or fully recessed cabinet as called for on drawings.

D. Front Panel: Bar grille constructed of minimum 16 gauge cold-rolled steel, welded into a uniform grille and finished in baked enamel. Front grille shall have a satin finished aluminum frame around the periphery.

E. Fan: Direct drive propeller type, statically and dynamically balanced.

F. Motor: Permanently lubricated sleeve bearings, totally enclosed, automatic reset thermal overload protection.

G. Control: Unit-mounted tamper-proof thermostat, thermal cutout, double-pole single throw unit mounted disconnect covered by protective front panel.

H. Acceptable Manufacturer: Trane, UHWA, Qmark Model AWH, Markel Series 3400, Berko Series FRC.

2.3 ELECTRIC UNIT HEATERS

A. Horizontal or vertical discharge as scheduled on the drawings.

B. Horizontal units shall have adjustable outlet louvers.

C. Metal sheathed fin tube electric heating elements.

D. Casing: Heavy gauge steel with baked enamel finish.

E. Automatic reset thermal overload wired for instantaneous pilot operation of contractor holding coil.

F. Motors shall be totally enclosed continuous duty with built-in thermal overload protection.

G. Provide unit mounted and wired disconnect.

H. Provide resiliently mounted fan guard/motor support.

I. Fans: Direct drive propeller type, factory balanced.

J. Acceptable Manufacturers: Trane, Chromalox, Modine, Reznor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturers' instructions.

2. Coordinate recess sizes for recessed equipment.

3. Protect units with protective covers during construction.

4. Comb all coils to repair bent fins.

B. Unit Heater:

1. Hang unit heaters from building structure, not from piping. Mount as high as possible within manufacturer’s recommended mounting height requirements. If unit heaters cannot be installed within manufacturer’s recommended range, notify Fermilab prior to mounting.

3.2 CLEANING

A. After construction is complete, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, with materials furnished by manufacturer.

C. Install new filters.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01810. Functional performance testing shall be performed by the subcontractor and witnessed and documented by the Commissioning Authority.

END OF SECTION 15835

SECTION 15865 - AXIAL FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vane Axial Fans.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Bear the AMCA Certified Rating Seal - Air Performance.

B. Fabrication: Conform to AMCA 99.

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

E. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

F. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

G. SMACNA - HVAC Duct Construction Standards, 1995 Edition.

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010. Include data on all axial fans and accessories, fan curves with specified operating points clearly plotted, and sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories.

B. Submit performance data for adjustable axial fan blades for at least five blade settings, including maximum.

C. Submit operation and maintenance data. Include instructions for lubrication, motor and drive replacement and spare parts list.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.6 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 VANE AXIAL FAN

A. In-line vane axial type, suitable for up to 3" static pressure, non-overloading.

B. Direct drive, drive sized for minimum 130% of motor horsepower. Select drives with operating point near the center of the adjustment range.

C. Internally mounted unless noted otherwise on drawings. ODH Exhaust Fans (EF-1, EF-2) shall include factory installed internally mounted variable speed AV vector duty motor. Refer to Motors Specification Section 15835 for more information. Motor shall be minimum 1/3 HP. Motor support brackets shall be welded to fan casing for increased strength.

D. Aluminum air foil blades, heliarc welded to aluminum hub. Statically and dynamically balanced. Blade pitch shall be manually adjustable without removing fan from casing.

E. Discharge straightening vanes welded in place.

F. Continuously welded steel casing with inlet and outlet flanges.

G. Regreasable bearings rated for 40,000 hour B-10 life at the design operating point, with lubrication lines extended outside of the housing.

H. Suitable for horizontal or vertical mounting.

I. Steel casing and structural components shall be coated with electrostatically applied thermosetting polyester urethane. Minimum coating thickness shall be 2 mils.

J. Fan shall include universal mounting supports and quick opening inspection door by manufacturer.

K. Acceptable Manufacturers: Greenheck AX, Cook, Aerovent, Joy, or New York Blower.

2.2 TUBE AXIAL FAN

A. In-line tube axial type, suitable for up to 3" static pressure, non-overloading.

B. Direct drive, drive sized for minimum 130% of motor horsepower. Select drives with operating point near the center of the adjustment range.

C. Internally mounted open drip-proof, ball bearing motor. Motor shall be minimum 1/3 HP. Motor support brackets shall be welded to fan casing for increased strength.

D. Aluminum air foil blades, heliarc welded to aluminum hub. Statically and dynamically balanced.

E. Continuously welded steel casing with inlet and outlet flanges.

F. Regreasable bearings rated for 40,000 hour B-10 life at the design operating point, with lubrication lines extended outside of the housing.

G. Suitable for horizontal or vertical mounting.

H. Manufacturer provided outlet guard where unit is not attached to ductwork. Attach guard directly to the fan.

I. Steel casing and structural components shall be coated with electrostatically applied thermosetting polyester urethane. Minimum coating thickness shall be 2 mils.

J. Fan shall include universal mounting supports and quick opening inspection door by manufacturer.

K. Acceptable Manufacturers: Greenheck TDI, Cook, Aerovent, Joy, or New York Blower.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fans have been test run under observation.

B. Install flexible connections between axial fans and ductwork. Ensure metal bands of connectors are parallel with minimum 1" flex between ductwork and axial fan while running.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01810. Functional performance testing shall be performed by the subcontractor and witnessed and documented by the Commissioning Authority.

END OF SECTION 15865

SECTION 15870 - POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. In-Line Cabinet Fan.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

E. SMACNA - HVAC Duct Construction Standards, 1995 Edition.

1.4 SUBMITTALS

A. Submit shop drawings per Section 15010. Include product data on wall and roof exhausters, and ceiling and cabinet fans.

B. Provide multi-rpm fan curves with specified operating point clearly plotted.

C. Submit manufacturer's installation instructions.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 IN-LINE CABINET FAN

A. Fiberglass lined, sheet metal housing, arranged for in-line installation.

B. Rubber torsion motor mounts.

C. Plug type disconnect.

D. Built-in backdraft damper.

E. Centrifugal fan.

F. Provide variable speed controller if shown on the drawings.

G. Acceptable Manufacturers: Greenheck CPS, ACME, Broan, Carnes, Cook, JencoFan, Penn.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof fan assemblies with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof fans to curbs with 1/4” lag bolts on 8” maximum centers.

D. M.C shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide and option to pre-wire the damper.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01810. Functional performance testing shall be performed by the subcontractor and witnessed and documented by the Commissioning Authority.

END OF SECTION 15870

SECTION 15890 - DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork
B. Ductwork Reinforcement
C. Ductwork Sealants
D. Rectangular Ductwork - Single Wall
E. Round Ductwork - Single Wall
F. Exposed Ductwork (Rectangular or Round)
G. Leakage Testing
H. Ductwork Penetrations
I. Painting

1.2 REFERENCES: Conform to all applicable requirements of the following publications:

A. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. ASHRAE - Handbook 2012 Systems and Equipment; Chapter 19 - Duct Construction.

C. ASHRAE - Handbook 2013 Fundamentals; Chapter 21 - Duct Design.

D. ASTM A90 - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.

E. ASTM A653 - Steel Sheet, Zinc-Coated (Galvanized) or zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

F. ASTM A924 - Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.

G. ASTM E90-02 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.

H. ASTM E413-87 - Classification for Rating Sound Insulation.

I. AWS D9.1M/D9.1 - Sheet Metal Welding Code.

J. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

K. NFPA 90B - Installation of Warm Air Heating and Air- Conditioning Systems.

L. SMACNA – Air Duct Leakage Test Manual – 1985 Edition.

M. SMACNA - HVAC Duct Construction Standards - 2005 Edition.

N. SMACNA - Round Industrial Duct Construction Standards - 1999 Edition.

O. UL 181 - Factory-Made Air Ducts and Air Connectors.

P. UL 181A - Closure Systems for Use With Rigid Air Ducts and Air Connectors

1.3 SUBMITTALS

A. Submit shop drawings per Section 15010.

B. Fermilab may require field verification of sheet metal gauges and reinforcing to verify compliance with these specifications. At the request of Fermilab, the subcontractor shall remove a sample of the duct for verification. The subcontractor shall repair as needed.

1.4 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 15010 for required duct systems electronic CAD drawings to be provided to Coordinating Subcontractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.

2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.

3. Location and size of all duct access doors.

4. Room names and numbers, ceiling types, and ceiling heights.

5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.

C. KJWW will provide electronic file copies of ventilation drawings for subcontractor’s use if the subcontractor signs and returns the “Electronic File Transfer” waiver attached at the end of this specification section. KJWW will not consider blatant reproductions of original file copies an acceptable alternative to coordination drawings. Architectural plans will need to be obtained from the Architect.

PART 2 - PRODUCTS

2.1 GALVANIZED DUCTWORK

A. General Requirements:

1. Duct and reinforcement materials shall conform to ASTM A653 and A924.

2. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.

3. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.

4. Ductwork reinforcement shall be of galvanized steel.

5. Ductwork supports shall be of galvanized or painted steel. Slip cable hangers are acceptable. Acceptable manufacturers are Gripple, Ductmate, Duro Dyne, or Fermilab approved.

6. All fasteners shall be galvanized or cadmium plated.

2.2 DUCTWORK REINFORCEMENT

A. General Requirements:

1. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

a. Ducts must be over 18” wide.

b. Duct dimensions must be increased 2” in one dimension (h or w) for each row of tie rods installed.

c. Tie rods must not exceed 1/2” diameter.

d. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.3 DUCTWORK SEALANTS

A. One part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000 hour minimum UV resistance per ASTM G-53.

B. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

C. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F. Acceptable manufacturers include: Venture Tape 1581A, Compac #340, Scotch Foil Tape 3326, Polyken 339.

2.4 RECTANGULAR DUCT - SINGLE WALL

A. General Requirements:

1. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.

2. Transitions shall not exceed the angles in Figure 4-7.

B. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

1. All ducts shall be cross-broken or beaded.

2. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

a. Type 1:

1) **Description**: Single wall type with 22-gauge (0.029”) or heavier vanes, 3-1/4" blade spacing, and 4” to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.

2) **Usage**: Limited to 3,000 fpm and vane lengths 36” and under.

b. Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.

c. Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.

d. Omitting every other vane is prohibited.

3. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type

RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. **Mitered elbows (with or without turning vanes) may not be substituted for radius elbows.** Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.

4. Rectangular branch and tee connections in ducts over 1” pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1” pressure class.

5. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.

6. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1” or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.

7. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.

8. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.

9. Cushion heads are acceptable only in ducts up to ± 2" pressure class, and must be less than 6” in length.

10. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

    a. Apply sealant to all inside corners. Holes at corners are not acceptable.

    b. Acceptable Manufacturers: Ductmate Industries - 25/35/45, Nexus, Mez, or WDCI. Other manufacturers must submit test data and fabrication standards and receive Fermilab’s approval before any fabrication begins.

11. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with

Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

a. Apply sealant to all inside corners. Holes at corners are not acceptable.

b. Flanges shall be 24-gauge minimum (not 26 gauge).

c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Fermilab's approval before any fabrication begins.

2.5 ROUND DUCTWORK - SINGLE WALL

A. Conform to applicable portions of Rectangular Duct Section. Round ductwork may be substituted for rectangular ductwork where approved by Fermilab. The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

B. Snap lock seams are not permitted.

C. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.

D. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.

E. Ductwork shall be suitable for velocities up to 5,000 fpm.

F. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.

G. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.

H. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.

I. Transverse Joint Connections:

1. Crimped joints are not permitted.

2. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.

3. Ducts and fittings larger than 36" shall have flanged connections.

4. Secure all joints with at least 3 sheet metal screws before sealing.

5. Slide-on flanges as manufactured by Ductmate Industries, Accuflange, or Sheet Metal Connectors are acceptable. Self-sealing duct systems are also acceptable (Lindab, Ward “Keating Coupling”).

2.6 EXPOSED DUCTWORK (RECTANGULAR OR ROUND)

A. The following applies to all ductwork exposed in finished areas in addition to requirements noted above:

1. Provide extra shipping protection. Use Cardboard or other protective means to prevent dents and deformed ends.

2. Provide cardboard or other means of protection during field fabrication. Protect from scratches. Provide stiffeners to retain shape during fabrication.

3. Remove all identification stickers and thoroughly clean exterior of all ducts.

4. Locate fitting seams on least visible side of duct.

5. Provide exterior finish suitable for field painting without further oil removal.

6. Provide ramp-type internal joint couplings. Provide bead of sealant around the inside of the duct about 1/2” from the end of the duct. Slide-on flanges as manufactured by Ductmate Industries, Accuflange or Sheet Metal Connectors are acceptable. Self-sealing duct system is also acceptable (Lindab, Ward “Keating Koupling”).

7. The system shall be free of visible dents and scratches when viewed from normal occupancy.

8. All insulation shall be internal.

B. Alternate manufacturers, including shop fabricated duct, must be reviewed before installation. The following information is required:

1. Metal gauge of duct and fittings.
2. Fitting type and construction.
3. Type and size of reinforcement.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms

D. During construction provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork.

E. Repair all duct insulation and liner tears.

F. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

G. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

H. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible.

I. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

3.2 DUCTWORK APPLICATION SCHEDULE

USAGE	**MATERIAL**	**PRESSURE CLASS**	**SEAL CLASS †**	**INSULATION** (Refer to Section 15290 for insulation types)
Supply Duct Interior from Fan to Outlet	Galvanized Sheet Metal - Rectangular	+2”	A	1" thick Type C
Supply Duct Interior from Fan to Outlet	Galvanized Sheet Metal - Round	+2”	A	1" thick Type G
Return Duct	Galvanized Sheet Metal	-2"	A	1" thick Type C
Exterior Return Duct	Galvanized Sheet Metal	-2”	A	2” thick Type B
General Exhaust Duct	Galvanized Sheet Metal	-1"	A	None
Exhaust Air Duct from fan to Exhaust Outlet	Galvanized Sheet Metal	+2"	A	None

USAGE	MATERIAL	PRESSURE CLASS	SEAL CLASS †	INSULATION (Refer to Section 15290 for insulation types)
Air Louver Ductwork to Backdraft Damper	Galvanized Sheet Metal	+2"	A	2" thick Type B

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.

2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.

3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.

4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer’s data sheet specifies other application methods or requirements.

B. For Seal Class A ducts, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

3.4 TESTING

A. Duct - 2" WG or Less (positive or negative):

1. Systems shall not leak more than shown in Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual for Seal Class A.

2. Leak testing of these systems is not normally required for interior ductwork. However, leak tests will be required if, in the opinion of Fermilab, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.

3. Leak test shall be at the Subcontractor's expense and shall require capping and sealing all openings.

4. Seal ducts to bring the air leakage into compliance.

5. Subcontractor shall notify Fermilab five business days prior to pressurizing ductwork for testing.

B. Test procedure shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

1. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.

2. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.

3. All joints shall be felt by hand, and all discernible leaks shall be sealed.

4. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.

5. Subcontractor shall notify Fermilab five business days prior to pressurizing ductwork for testing. Failure to notify Fermilab of pressure testing may require the subcontractor to repeat the duct pressure test after proper notification.

6. Upon completion of the pressure test, the subcontractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

7. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.

8. The required leakage class for Seal Class A, both round and rectangular ducts, shall be 4.

9. Positive pressure leakage testing is acceptable for negative pressure ductwork.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Fermilab.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms.

3.6 PAINTING

A. Paint interior of ducts black within twice the largest duct dimension of inlets and outlets where interior of duct is visible.

END OF SECTION 15890

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SECTION 15910 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual Volume Dampers.
B. Backdraft Dampers.
C. Fabric Connectors.
D. Duct Access Doors.
E. Duct Test Holes.

1.2 REFERENCES

A. ASTM E477-06a - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

B. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

C. SMACNA - HVAC Duct Construction Standards – Third Edition - 2005.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 15010.

B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME DAMPERS

A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

B. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inches.

C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide molded synthetic or oil-impregnated nylon or sintered bronze bearings.

E. Provide locking quadrant regulators on single and multi-blade dampers.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. If blades are in open position and extend into the main duct, mount damper so blades are parallel to airflow.

2.2 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 inches x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

B. 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 90º stop, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

C. Acceptable Models: Ruskin CBD4, Arrow 655, Safe-Air/Dowco BRL, Greenheck EM.

2.3 FABRIC CONNECTORS

A. Fabric connectors shall be installed between all fans or fan units and metal ducts or casings to prevent transfer of fan or motor vibration.

B. The fabric connectors shall be completely flexible material which shall be in folds and not drawn tight.

C. Fabric connectors shall be of glass fabric double coated with neoprene, with UL approval. Weight = 30 oz. per square yard minimum. Fabric shall not be affected by mildew and shall be absolutely waterproof, airtight and resistant to acids, alkalies, grease and gasoline, and shall be noncombustible.

D. Fabric connections shall not exceed 6" in length on ductwork that has a positive pressure. On ductwork that has a negative pressure, the length shall not exceed 2" in length.

E. All corners shall be folded, sealed with mastic and stapled on 1" centers.

F. Fabric connectors shall not be painted.

G. Unless otherwise shown on the drawings, the fabric connection at the inlet to centrifugal fans shall be at least one duct diameter from the fan to prevent inlet turbulence.

H. Acceptable Materials: Durodyne MFN-4-100, Vent Fabrics, Inc. "Ventglas", or Proflex PFC3NGA.

2.4 DUCT ACCESS DOORS

A. Fabricate per Fig. 7-2 and 7-3 of the SMACNA HVAC Duct Construction Standards and as indicated.

B. Review locations prior to fabrication. Install access doors at fire dampers, smoke dampers, motorized dampers, fan bearings, filters, automatic controls, humidifiers, louvers, duct coils and other equipment requiring service inside the duct.

C. Construction shall be suitable for the pressure class of the duct. Fabricate rigid, airtight, and close-fitting doors of materials identical to adjacent ductwork with sealing gaskets butt or piano hinges, and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors with sheet metal screw fasteners are not acceptable.

E. Minimum size for access doors shall be 24" x16" or full duct size, whichever is less.

F. Provide quantity of access doors such that two hands can fit inside ductwork to manually reset fire dampers. This will typically require one access door on the bottom and one access door on an accessible side of the duct for sizes 12x12 and smaller.

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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install accessories in accordance with manufacturer's instructions.

2. Coordinate and install access doors provided by others.

3. Provide access doors for all equipment requiring maintenance or adjustment above an inaccessible ceiling. Minimum size shall be 24” x 24”.

4. Provide duct test holes where indicated and as required for testing and balancing purposes.

B. Manual Volume Damper:

1. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts where indicated on drawings and as required for air balancing.

2. Provide ceiling access doors for manual volume dampers. When manual volume dampers are located above an inaccessible ceiling and an access door cannot be installed, provide a remote controlled volume control device for operation of the damper. Coordinate location with Fermilab.

END OF SECTION 15910

SECTION 15936 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Grilles And Registers.
B. Architectural Square Panel Diffusers.
C. Louvers.

1.2 QUALITY ASSURANCE

A. Test and rate performance of air inlets and outlets per ASHRAE 70.

B. Test and rate performance of louvers per AMCA 500L-99.

C. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REFERENCES

A. AMCA 500L-07 - Test Method for Louvers, Dampers and Shutters.

B. ANSI/ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Inlets and Outlets.

C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. SMACNA - Duct Construction Standards.

1.4 SUBMITTALS

A. Submit product data under provisions of Section 15010.

B. Submit schedule of inlets and outlets indicating type, size, location, application, and noise level.

C. Review requirements of inlets and outlets as to size, finish, and type of mounting prior to submitting product data and schedules of inlets and outlets.

D. Submit manufacturer's installation instructions.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

B. Conform to ASHRAE 90.1.

PART 2 - PRODUCTS

2.1 GRILLES AND REGISTERS

A. Reference to a grille means an air supply, exhaust or transfer device without a damper.

B. Reference to a register means an air supply, exhaust or transfer device with a damper.

C. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule and suitable for the intended use.

D. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents shall be brought to the attention of Fermilab, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

E. The capacity and size of the unit shall be as shown on the drawings.

F. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect.

G. Refer to the drawings for construction material, color and finish, margin style, deflection, and sizes of grilles and registers.

H. Provide with 3/4” blade spacing. Blades shall have steel friction pivots to allow for blade adjustment, plastic pivots are not acceptable.

I. Corners of steel grilles and registers shall be welded and ground smooth before painting. Aluminum grilles and registers shall have staked corners.

J. Where specified to serve registers, provide opposed blade volume dampers operable from the face of the register.

K. Screw holes for surface fasteners shall be countersunk for a neat appearance. Provide concealed fasteners for installation in lay-in ceilings and as specified on the drawings.

L. Acceptable Manufacturers: Tuttle & Bailey, Titus, Price, Nailor, Carnes, Metalaire, Krueger.

2.2 LOUVERS - FIXED - ALUMINUM

A. Louvers shall be minimum 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be minimum 0.081". Blades shall be spaced at a maximum of 5.1" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. AMCA Certified performance for 48" x 48" samples with intake airflow of 8,000 cfm shall not exhibit more than 0.19" pressure drop. Maximum water penetration shall be 0.01 ounces per square foot at the scheduled intake velocity based on 15 minute test duration when subjected to a water flow rate of 0.25 gal/min as described under the Water Penetration Test in AMCA 500-L-07.

F. Subcontractor shall provide the General Subcontractor with the correct sizes and locations of all louvers required in masonry walls.

G. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall.

H. Louvers shall be suitable for duct connection.

I. Acceptable Manufacturers: Air Flow - “EA-403”, Arrow - “EA-415-D", American Warming & Ventilating - “LE-21", Construction Specialties - “A4097", Dowco - “DBE-4", Louvers & Dampers, Inc. - “IL-23", Ruskin - “ELF375DX”, Vent Products - “2760", Greenheck - “ESD-403", Pottorff - “EFD”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install items in accordance with manufacturers' instructions.

2. Check location of inlets and outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3. Install diffusers to ductwork with air tight connections.

B. Volume Damper:

1. Provide manual volume dampers on duct take-off to diffusers when there are multiple connections to a common duct. Locate volume dampers as far as possible from the air inlet or outlet.

END OF SECTION 15936

SECTION 15952 - CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Complete System of Automatic Controls.
B. Control Devices, Components, Wiring and Material.
C. Instructions for Fermilab.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.

B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.

C. Technician: Minimum five years' experience installing commercial temperature control systems.

D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

1.3 REFERENCES

A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ANSI/ASHRAE Standard 135-2001: BACnet® – A Data Communication Protocol for Building Automation and Control Networks, including all amendments.

D. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 volts Maximum).

E. ANSI/NFPA 70 - National Electrical Code.

F. ANSI/NFPA 90A - Installation of Air-Conditioning and Ventilation Systems.

G. ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality.

H. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.

I. ASTM D1693 - Environmental Stress - Cracking of Ethylene Plastics.

1.4 SUBMITTALS

A. Equipment Coordination:

1. The Controls Subcontractor shall obtain approved equipment submittals from other subcontractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.

2. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.

B. Shop Drawings:

1. Submit shop drawings per Section 15010. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to Fermilab for review.

2. Cross-reference **all** control components and point names in a single table located at the beginning of the submittal with the **identical** nomenclature used in this section.

3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.

4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.

5. Diagrams shall include:

a. Wiring diagrams and layouts for each control panel showing all termination numbers.

b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.

c. Identification of all control components connected to emergency power.

d. Schematic diagrams for all field sensors and controllers.

e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.

f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.

g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.

h. All installation details and any other details required to demonstrate that the system will function properly.

i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. **The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by Fermilab. Clearly highlight any deviations from the specified sequences on the submittals.**

8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.

9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:

a. Damper Identification Tag.
b. Location.
c. Damper Type.
d. Damper Size.
e. Duct Size.
f. Arrangement.
g. Blade Type.
h. Velocity.
i. Pressure Drop.
j. Fail Position.
k. Actuator Identification Tag.

l. Actuator Type.
m. Mounting.

10. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies 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 to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.

11. Provide PICS files indicating the BACnet® functionality and configuration of each device.

12. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements in the event that problems are found during BTL testing is required.

13. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.

14. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.

15. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with <u>all</u> reports and checklists to be used.

16. Clearly identify work by others in the submittal.

17. Quantities of items submitted may be reviewed but are the responsibility of the Subcontractor to verify.

C. Operation and Maintenance Manual:

1. In addition to the requirements of Section 15010, submit an electronic copy of the O&M manuals in PDF format.

2. Provide three complete sets of manuals.

3. Each O&M manual shall include:

   a. Table of contents with indexed tabs dividing information as outlined below.

   b. Definitions: List of all abbreviations and technical terms with definitions.

   c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of subcontractors installing equipment and controls and service representatives of each.

   d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.

   e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.

   f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.

   g. Programming: 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.

   h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.

   i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

   j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.

   k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Section 15010.

2. Provide a complete set of “as-built” drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the “as-built” drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.

3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.

4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.

5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.5 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

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

1.6 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Temperature Sensor Sockets.
B. Gauge Taps.
C. Automatic Dampers.
D. Airflow Sensors.

1.7 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 “Signal Equipment.”

3. EMC Directive 89/336/EEC (European CE Mark).
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.8 ACRONYMS

A. Acronyms used in this specification are as follows:

1. B-AAC BACnet Advanced Application Controller
2. B-ASC BACnet Application Specific Controller
3. BTL BACnet Testing Laboratories
4. DDC Direct Digital Controls
5. FMCS Facility Management and Control System
6. GUI Graphic User Interface
7. IBC Interoperable BACnet Controller
8. IDC Interoperable Digital Controller
9. LAN Local Area Network
10. NAC Network Area Controller
11. ODBC Open DataBase Connectivity
12. OOT Object Oriented Technology
13. OPC Open Connectivity via Open Standards
14. PICS Product Interoperability Compliance Statement
15. PMI Power Measurement Interface
16. POT Portable Operator's Terminal
17. TCC Temperature Control Subcontractor
18. TCS Temperature Control System
19. WAN Wide Area Network
20. WBI Web Browser Interface

1.9 SUMMARY

A. Extend existing Fermilab Campus system.

1. Extend existing FMCS for this project.

2. All controllers and accessories shall interface with the existing FMCS control system.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to Fermilab.

D. Fermilab shall be the named license holder of all software associated with any and all incremental work on the project.

1.10 SYSTEM DESCRIPTION

A. Extend the existing Fermilab Johnson Controls Metasys Building Automation System (BAS) to serve the new building and incorporate the scope of work described in the specifications and shown on the drawings.

B. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

C. The FMCS shall include a Johnson Controls NAE-5510-2 Controller (NAC). The NAC shall connect to Fermilab's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

D. Provide materials and labor necessary to connect factory supplied control components.

E. Provide central and remote hardware, software, and interconnecting wire and conduit.

F. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by Fermilab.

G. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

1.11 SOFTWARE LICENSE AGREEMENT

A. Fermilab shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, Fermilab shall receive Fermilabship of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide Fermilab with all required IDs and passwords for access to any component or software program. Fermilab shall determine which organizations shall be named in the SI organization ID (**"orgid"**) of all software licenses. Fermilab shall be free to direct the modification of the **"orgid"** in any software license, regardless of supplier.

1.12 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It

is this Subcontractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.13 WARRANTY

A. Refer to Section 15010 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Subcontractor at no expense to Fermilab.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on Fermilab's archived software disks.

1.14 WARRANTY ACCESS

A. Fermilab shall grant to this Subcontractor reasonable access to the TCS and FMCS during the warranty period.

1.15 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Johnson Controls: Metasys Extended Architecture.

1. Contact: Steve Green (224) 325-6210.

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, network devices, valves, dampers, sensors, and other devices as specified herein.

2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true “peer-to-peer” communicating devices. Components or controllers requiring “polling” by a host to pass data are not acceptable.

2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.

3. Hierarchical or “flat” topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer’s internal intranet network.

a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE Standard 802.3.
2. Cable; 100 Base-T, UTP-8 wire, Category 5.
3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and “safed” off in an appropriate manner.

E. There shall be no power wiring in excess of 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with

communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. Fermilab shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) Johnson Controls NAE-5510-2 as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 15 and 16. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all controller data.
7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:

1. One Ethernet Port – 10/100 Mbps.
2. One RS-232 port.
3. One RS-485 port.
4. Battery backup.
5. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
6. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
7. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
8. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:

1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.

2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.

3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

a. Alarm
b. Normal

4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.

5. Provide timed (scheduled) routing of alarms by class, object, group, or node.

6. Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:

1. Screen message text.

2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e-mail alarms based on:

a. Day of week.
b. Time of day.
c. Recipient.

3. Pagers via paging services that initiate a page on receipt of e-mail message.

4. Graphic with flashing alarm object(s).

5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:

1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a “query” feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):

1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system’s compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.

2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:

   a. BACnet Building Controller(s) (B-BC).
   b. BACnet Advanced Application Controller(s) (B-ACC).
   c. BACnet Application Specific Controller(s) (B-ASC).

3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.

4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.

5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.

6. The Subcontractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:

   a. BACnet Device; MAC address, name, type and instance number.
   b. BACnet Objects; name, type and instance number.

7. It is the responsibility of the Subcontractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.

2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.

4. All control objects shall conform to the control objects specified in the BACnet specification.

5. The library shall include applications or objects for the following functions, at a minimum:

   a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.

   b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic “point-and-click” selection. This object must be “linkable” to any or all scheduling objects for effective event control.

   c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.

   d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building’s “flywheel” effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.

   e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user’s screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a

minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:

a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.

b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.

c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an “on” condition. The user must be able to specify either input condition as the “on” condition.

d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.

e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.

f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.

g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object

behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.

i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.

j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an “on” state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.

k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the “contained” application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:

a. For BACnet devices, provide the following objects:

1) Analog In.
2) Analog Out.
3) Analog Value.
4) Binary.
5) Binary In.
6) Binary Out.
7) Binary Value.
8) Multi-State In.

9) Multi-State Out.
10) Multi-State Value.
11) Schedule Export.
12) Calendar Export.
13) Trend Export.
14) Device.

b. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

c. For BACnet devices, provide the following support at a minimum:

1) Segmentation.
2) Segmented Request.
3) Segmented Response.
4) Application Services.
5) Read Property.
6) Read Property Multiple.
7) Write Property.
8) Write Property Multiple.
9) Confirmed Event Notification.
10) Unconfirmed Event Notification.
11) Acknowledge Alarm.
12) Get Alarm Summary.
13) Who-has.
14) I-have.
15) Who-is.
16) I-am.
17) Subscribe COV.
18) Confirmed COV notification.
19) Unconfirmed COV notification.
20) Media Types.
21) Ethernet.
22) BACnet IP Annex J.
23) MSTP.
24) BACnet Broadcast Management Device (BBMD) function.
25) Routing.

2.7 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.

2. For interval logs, configure the object for time of day, day of week and the sample collection interval.

3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.

4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.

5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.

C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

D. All log data shall be available to the user in ALL the following data formats:

1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

2.8 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.9 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.10 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:

1. The GUI shall run on the most current Microsoft based operating system with which the GUI has been proven compatible.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.

C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Fermilab.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.

2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.

3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.

4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.

a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.

b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.

5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.

6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects.
3. Tune control loops by adjusting control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select alarm points and define the alarm state.
7. Select points to be trended and initiate the recording of values automatically.
8. View any trend as a graph.

F. On-Line Help: 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 applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that 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 administrator shall be able to set passwords and 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 be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:

1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.

2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.11 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Chrome.

Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.

2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.

3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.

5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

a. Modify common application objects, such as schedules, calendars, and setpoints, graphically.

1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.

2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.

b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.

c. View logs and charts.

d. View and acknowledge alarms.

e. Setup and execute SQL queries on log and archive information

7. The system shall be able to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.

8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

2.12 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for each of the following:

1. Network area controllers.

B. Provide a 120 volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Acceptable Manufacturers: Sola/Hevi-Duty, Eaton Powerware, APC.

2.13 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user's application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.

2. Configuration of each object shall be done through the object's property sheet using fill-in-the-blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.

3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.

5. The system shall support object duplication in a customer's database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.14 DDE DEVICE INTEGRATION

A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.15 SOFTWARE

A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control algorithms and specific control sequences (IDC/IBC) and an Fermilab/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:

1. Time of day scheduling.
2. Optimum start/stop.
3. Peak demand limiting.
4. Economizer control.
5. PID control.
6. Supply air reset.
7. Outdoor air reset.

E. Input/output point processing software shall include:

1. Update of all connected input and output points at least once per second.

2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.

3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.

4. Assignment of proper engineering units and status conditions to all inputs and outputs.

5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.

6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.

1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.

2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.

3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed

mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non-volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:

1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.

3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.

4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a fail safe position on start-up.

L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:

1. Analog points commandable to a specific value.

2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.

3. Initiator to be a specific day and time or a specific event; e.g. an alarm.

4. Manual initiation via operator's command.

5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.

6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.

7. Ability to chain TEPs.

8. Ability to enable and disable TEPs individually.

9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:

1. Time Programs:

a. Provide an independent start and stop program time for each system identified in the points list.

b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.

2. Exception Day Scheduling:

a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.

b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.

3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:

   a. Ability to alter time schedules as much as six days in advance.

   b. Ability to alter either start time, stop time or both for each day.

   c. Temporary schedule shall be in effect for all days specified.

   d. Automatically delete the temporary schedule and restore program to normal schedule after execution.

   e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:

1. Standard locally stocked modular boards.
2. Plug-in type.
3. Furnish all ROM programs unlocked.

2.16 CONTROL DAMPERS

A. Rectangular Control Dampers - Standard Construction:

1. Shall be licensed to bear the AMCA Certified Rating Seal.

2. Test leakage and pressure drop per AMCA 500.

3. Frame: Hat-shaped channel, minimum 12 gauge extruded aluminum, and minimum 4” deep. Caulk or weld seams to prevent leakage.

4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6” wide, and overlapping blades and blade seals (overlapping blade seals only is unacceptable).

5. Shaft: Non-cylindrical, solid aluminum shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.

6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.

7. Blade Seals: Extruded silicone gaskets secured in an integral slot within the blade.

8. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.

9. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.

10. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.

11. Maximum Leakage: 9 cfm at 1” w.c. pressure differential for a 24”x24” damper.

12. Maximum Pressure Drop for Opposed Blade Damper: 0.15" for 8,000 cfm through a 24"x24" damper (2000 fpm).

13. Maximum Pressure Drop for Parallel Blade Damper: 0.08" for 8,000 cfm through a 24"x24" damper (2000 fpm).

B. Thermally Insulated Control Damper:

1. Shall be licensed to bear the AMCA Certified Rating Seal.

2. Test leakage and pressure drop per AMCA 500.

3. Thermally Broken Frame: Extruded aluminum, minimum 4” deep, 0.080” minimum thickness. Insulate frame with extruded polystyrene on four sides and flanged to duct. Entire frame shall be thermally broken using polyurethane resin pockets, complete with thermal cuts.

4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6” wide, internally insulated with expanded polyurethane foam and thermally broken, with overlapping blades and blade seals (overlapping blade seals only is unacceptable).

5. Shaft: Non-cylindrical, solid aluminum shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.

6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.

7. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.

8. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.

9. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.

10. Maximum Leakage: 15 cfm at 1” w.c. pressure differential for a 24”x24” damper.

11. Maximum Pressure Drop: 0.21” for 8,000 cfm through a 24”x24” damper (2000 fpm).

2.17 DAMPER ACTUATORS

A. Damper Actuators - Electronic - Spring Return:

1. Damper actuators shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and “V” bolt clamp with matching “V” toothed cradle (single bolt or setscrew fasteners not acceptable).

2. Following power interruption, spring return mechanism shall close the damper. Mechanical spring shall be rated for a minimum of 60,000 full cycles. Provide breathable membrane in actuator housing to compensate for pressure differential and allow for 95% non-condensing relative humidity in the airstream.

3. Mount actuators with motor outside of airstream whenever possible. Unit casings shall have housing with proper weather, corrosive, or explosion-proof construction as required by application.

4. Actuators shall be rated for 60,000 full cycles at rated torque with 2-year unconditional warranty. Size actuators per damper manufacturer’s recommendations.

5. Provide end switches as required for the sequence of operation.

6. Provide analog feedback signal for positive position indication. Refer to FMCS points list.

2.18 CONTROL INSTRUMENTATION

A. Temperature Sensors:

1. Room Temperature Sensor:

a. Sensor Only: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, no setpoint adjustment or override button.

2. Duct Temperature Sensor:

a. Thermistor or RTD type. Pneumatic transmitters with transducers are not acceptable.

B. Humidity Measuring Devices:

1. Humidity Sensors:

a. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service. Accuracy shall be ± 2% of reading.

C. Pressure Measuring Devices

1. Pressure Transmitters/Transducer:

a. Select device suitable for intended application; water or air, static or differential.

b. Select for appropriate range, including negative if applicable.

c. 100% solid state device, temperature compensated, suitable for pressures of 200% rated range with averaging to stabilize output, accuracy of ± 1% full scale, and a 4-20 mA output.

d. Provide a NEMA 4 enclosure unless panel mounted.

e. Air service shall have a minimum of three field selectable ranges.

f. When used for room pressure control, the transducer shall be bidirectional with a range of ± 0.1” W.C.

g. Provide pressure line outlet cover on both sides of the wall when used for room pressure control.

h. Furnish with integral LED’s to indicate Zero Pressure, Pressure In Range, and Pressure Out Of Range as a diagnostic aid.

D. Current Measuring Devices:

1. Current Switches for Constant Speed Motors:

a. Digital device rated for amperage load of motor or device with split core design, adjustable high and low trip points, 600 VAC rms isolation, induced power from the monitored load, LED indicator lamps for output status and sensor power. The device shall sense overloading, belt-loss, and power failure with a single signal.

2. Current Switches for Motors Controlled by VFD:

a. Digital device rated for amperage load of motor or device with split core design, factory programmed to detect motor undercurrent conditions on variable or constant volume loads, self-calibrating, positive status indication, LED indicator lamps, 600 VAC rms isolation, induced power from the monitored load with N.O. output. The current sensor shall store the motor current operating parameters in non-volatile memory and have a pushbutton reset to clear the memory if the operating parameters change or the sensor is moved to another load. The device shall sense overloading, belt-loss, and power failure with a single signal. The sensor shall be mounted on the load side of variable frequency drives.

E. Miscellaneous Devices:

1. Airflow Sensor for ODH Fans:

a. Duct mounted, cylindrical type sensors and adjustable trip points. LED status indicator lamps.

b. Relay is energized when flow is present to prove fan operation.

c. Acceptable Manufacturer 8 Model: Efector 300 SL5101 or approved equal.

2. Control Relays:

a. Form “C” contacts rated for the application with “push-to-test" contact transfer feature and an integral LED to indicate coil energization.

b. Mount all relays and power supplies in a NEMA 1 NEMA 12 enclosure beside the FMCS panel or controlled device and clearly label their functions.

2.19 CONDUIT

A. All control wiring shall be in blue conduit. Confirm conduit color selection with Fermilab.

B. Conduit and Fittings: Refer to Electrical Section 16111 for materials and sizing.

2.20 WIRE AND CABLE

A. Wire and Cable Materials: Refer to Electrical Section 16120 for wire and cable materials.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed 48”.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall not be powered from the life safety branch of the emergency power system. Coordinate emergency power source connections with Fermilab.

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.

2. Labels may be made with permanent marking pen in the control panels if clearly legible.

3. Use engraved labels for items outside panel such as outside air thermostats.

4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

N. VFD's:

1. This project includes several variable frequency drives to control the flow of fans based on a control variable. Confirm control contacts and communication control interface requirements with Fermilab. ODH group for drives which control ODH equipment as indicated on drawings.

2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.

3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.

4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.

5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.

B. Components shall be arranged on graphic as installed in the field.

C. Include each graphic point listed in the itemized points list using real time data.

D. Provide a graphic representation of the following:

1. Provide an overall floor plan of each floor of the building color coded by zone linked to the RTU for that zone. The zone shall be linked to the graphic for that zone's RTU graphic.

2. Show the location of each thermostat on the floor plan.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:

1. Home page to include a minimum of six critical points: Outside Air Temperature, Room Temperature and Relative Humidity, etc.

2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.

3. Detailed graphics for each mechanical system including RTUs, supply fans, exhaust fans, and motor operated dampers, as a minimum.

4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:

1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.

2. TCS Bill of Material for each system, e.g. RTU, CAB, UH, etc.

3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT INSTALLATION

A. Conduit Sizing and Installation: Refer to Electrical Section 16111 for execution and installation.

1. Thermostats/temperature sensors shall be installed in junction boxes, flush with the wall, and shall be coordinated for orientation with Fermilab.

3.4 WIRE AND CABLE INSTALLATION

A. Wire and Cable Materials Installation: Refer to Electrical Section 16120 for execution and installation.

B. Field Quality Control:

1. Inspect wire and cable for physical damage and proper connection.

2. Torque test conductor connections and terminations to manufacturer's recommended values.

3. Perform continuity test on all conductors.

4. Protection of cable from foreign materials:

a. It is the Subcontractor's responsibility to provide adequate physical protection to prevent foreign material application or

contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Subcontractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), Fermilab may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Subcontractor shall also present to Fermilab a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

C. Installation Schedule:

1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquidtight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment.

3.5 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Fermilab standards. In the absence of Fermilab standards, naming conventions shall use equipment designations shown on plans.

3.6 COMMISSIONING

A. Upon completion of the installation, this Subcontractor shall load all system software and start up the system. This Subcontractor shall perform all necessary

calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. This Subcontractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the FMCS system operation.

C. This Subcontractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Fermilab's Representative, as required. Properly schedule these tests so testing is complete at a time directed by Fermilab's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Subcontractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of Fermilab’s Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

F. System functional performance testing is part of the Commissioning Process as specified in Section 01810. Functional performance testing shall be performed by the subcontractor and witnessed and documented by the Commissioning Authority.

3.7 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified.

E. Verify the operation of all interlock systems.

3.8 TEST AND BALANCE COORDINATION

A. The Subcontractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Subcontractor shall provide a minimum of four (4) hours training for the Balancing Subcontractor in the use of these tools.

C. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.9 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.10 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 8 hours of training on consecutive days for 4 Fermilab's representatives. The training course shall enable Fermilab's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand FMCS systems components.
4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log-on and off the system.
7. Access graphics, point reports, and logs.
8. Adjust and change system setpoints, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.
10. Understand system drawings and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
12. Access data from FMCS controllers and ASC's.
13. Operate portable operator's terminals.

C. Advanced Operations - Training Description:

1. Make and change graphics on the workstation.
2. Create, delete, and modify alarms, including annunciation and routing of these.
3. Create, delete and modify point trend logs and graph or print these both on and ad-hoc basis and at user-definable time intervals.
4. Create, delete, and modify reports.
5. Add, remove, and modify system's physical points.
6. Create, modify and delete programming.
7. Add panels when required.
8. Add operator interface stations.
9. Create, delete, and modify system displays, both graphic and others.

10. Perform FMCS system field checkout procedures.
11. Perform FMCS controller unit operation and maintenance procedures.
12. Perform workstation and peripheral operation and maintenance procedures.
13. Perform FMCS system diagnostic procedures.
14. Configure hardware including PC boards, switches, communication, and I/O points.
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
16. Adjust, calibrate, and replace system components.

D. System Management - Training Description:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

E. Provide course outline and materials in accordance with the “SUBMITTALS” article in Part 1 of this section. The instructor(s) shall provide one copy of training material per student.

3.11 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer’s recommendations.

B. Mount sensors rigidly and adequately 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 raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. All pipe-mounted temperature sensors shall be installed in immersion wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

F. Install outdoor air temperature sensors on exterior of north wall, complete with sun shield at designated location approved by Fermilab. TCC shall prime and paint the device enclosure. Color selection by Fermilab.

END OF SECTION 15952

SECTION 15980 - INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Positive Displacement Meters.
B. Pressure Gauge.
C. Pressure Gauge Accessories.
D. Thermometers.
E. Test Plugs.
F. Static and Differential Airflow Pressure Gauges.

1.2 REFERENCES

A. ANSI/AWWA C700 - Cold Water Meters - Displacement Type, Bronze Main Case.

B. ANSI/AWWA C706 - Direct Reading, Remote Registration Systems for Cold Water Meters.

C. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.

D. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.

E. ASTM E1 - Specification for ASTM Thermometers.

1.3 SUBMITTALS

A. Submit shop drawings per Section 15010. Include list that indicates use, operating range, total range and location for manufactured components.

PART 2 - PRODUCTS

2.1 POSITIVE DISPLACEMENT METERS (LIQUID)

A. AWWA C700 positive displacement disc type suitable for fluid with hermetically sealed register, remote reading to AWWA C706.

B. Provide water meters with bronze case with cast iron frost-proof, breakaway bottom cap.

C. Water meter shall be capable of communicating usage to Schneider Electric Powerlogic electrical meter and associated integrated utility information system. Refer to control diagrams on drawings for more information.

D. Acceptable Manufacturers: Neptune, Badger, or Hersey.

2.2 PRESSURE GAUGES

A. Gauges shall be 4-1/2" diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for air, steam, water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze bushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

B. Acceptable Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Trerice, U.S. Gauge Figure 1901, Weiss, Weksler, Wika.

C. Select gauge range for normal reading near center of gauge.

2.3 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4" ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4" connections, porous metal type.

2.4 THERMOMETERS

A. Alcohol/Spirit Filled Type:

1. 9" long phenolic case, steel stem, accuracy of 1% full scale. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.

2. Select thermometer for appropriate temperature range.

3. Stem lengths as required for application with minimum insertion of 3-1/2".

4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Wells shall extend through insulation. Thermometers for air shall have an aluminum or brass duct flange.

5. Acceptable Manufacturer: Marsh, Miljoco, Trerice, Weiss, Weksler, Wika.

B. Select scales to cover expected range of temperatures.

2.5 TEST PLUGS

A. Test Plug: 1/4" or 1/2" brass fitting and cap, with Nordel core for temperatures up to 275°F, for receiving 1/8" outside diameter pressure or temperature probe. Plugs shall be rated for zero leakage from vacuum to 500 psi.

B. Provide extended units for all plugs installed in insulated piping.

C. Test Kit: Carrying case, internally padded and fitted containing one 3-1/2" diameter pressure gauge with 0-100 psi range, one gauge adapter with 1/8"

probes, two 1-1/2" dial thermometers with 0° to 220°F and -25°F to 125°F ranges and 5" stems.

D. Acceptable Manufacturers: Sisco, Flow Design, or Peterson Equipment.

2.6 STATIC AND DIFFERENTIAL AIRFLOW PRESSURE GAUGES

A. Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig.

B. Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F.

C. Provide mounting brackets, probes, and shutoff valves required for proper installation.

D. The range and service shall be as required for application or as noted on the drawings.

E. Acceptable Manufacturers: Dwyer Magnehelic Series 2000, Marshalltown Instrument Series 85C.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.

2. Coil and conceal excess capillary on remote element instruments.

3. Install gauges and thermometers in locations where they are easily read from normal operating level.

4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Positive Displacement Meters:

1. Install positive displacement meters with shutoff valves on inlet and outlet. Provide full line size valved bypass with globe valve for liquid service meters.

C. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.

2. Provide snubber for each pressure gauge.

3. Provide coil syphon for each pressure gauge connected to steam piping.

D. Thermometers:

1. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2" for installation of thermometer sockets.

2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.

3. Locate duct thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

END OF SECTION 15980

SECTION 15990 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.
B. Measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance, 2002.

B. ADC – Test Code for Grilles, Registers, and Diffusers.

C. AMCA – Publication 203-90; Field Performance Measurement of Fan Systems.

D. ASHRAE - 2003 HVAC Applications Handbook; Chapter 37, Testing, Adjusting and Balancing.

E. ASHRAE/ANSI - Standard 111-1988; Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.

F. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, Sixth Edition, 1998.

G. SMACNA - HVAC Systems; Testing, Adjusting and Balancing, Third Edition, 2002.

H. TABB – International Standards for Environmental Systems Balance.

1.4 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Submit four (4) certified copies of test reports to Fermilab for approval in soft cover, 3-hole binder manuals, with cover identification. Include index page and indexing tabs.

1.5 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by Fermilab when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.6 WARRANTY/GUARANTEE

A. The TAB Subcontractor shall include an extended warranty of 90 days after Fermilab receipt of a completed balancing report, during which time Fermilab may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 manhours of on site service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days notice to all trades and Fermilab prior to performing each test.

1.8 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01810 Commissioning. Testing of these systems is required, in cooperation with Fermilab and the Commissioning Authority. Refer to Section 01810 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in Paragraph 1.2. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under

the contract documents shall be balanced using a procedure from a published standard listed in Paragraph 1.2.

B. Recorded data shall represent actual measured or observed conditions.

C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

D. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

F. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

a. Equipment is safe to operate and in normal condition.
b. Equipment with moving parts is properly lubricated.
c. Temperature control systems are complete and operable.
d. Proper thermal overload protection is in place for electrical equipment.
e. Direction of rotation of all fans is correct.
f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

a. All filters are clean and in place. If required, install temporary media.
b. Duct systems are clean and free of debris.
c. Manual volume dampers are in place, functional and open.
d. Air outlets are installed and connected.
e. Duct system leakage has been minimized.

B. Report any defects or deficiencies to Fermilab.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. 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 Fermilab for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.

B. + 5% of scheduled values

1. Adjust outdoor air intakes to within + 5% of scheduled values.

C. Adjust supply, return, and exhaust air-handling systems to +10% of scheduled values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Subcontractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with subcontractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (KJWW Engineering Consultants).
5. Project General Subcontractor.
6. TAB Company name, address, phone number.

7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.2 AIR SYSTEMS

A. Duct Leakage Test:

1. Air system and fan.
2. Leakage class.
3. Test pressure.
4. Construction pressure.
5. Flow rate (cfm): specified and actual.
6. Leakage (refer to Section 15890 in the specifications): specified and actual.
7. Statement that fire dampers and other accessories were included in the test.
8. Pass or Fail.
9. Test performed by.
10. Test witnessed by.

B. Air Moving Equipment:

1. General Requirements:
   a. Drawing symbol.
   b. Location.
   c. Manufacturer, model, arrangement, class, discharge.
   d. Fan RPM.
   e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
   f. Final frequency of motor at maximum flow rate (on fans driven by VFD).

2. Flow Rate:
   a. Supply flow rate (cfm): specified and actual.
   b. Return flow rate (cfm): specified and actual.
   c. Outside flow rate (cfm): specified and actual.
   d. Exhaust flow rate (cfm): specified and actual.
3. Pressure Drop and Pressure:
   a. Filter pressure drop: specified and actual.
   b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
   c. Inlet pressure.
   d. Discharge pressure.

C. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.
5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure.
7. Discharge pressure.
8. Fan RPM.

D. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

E. Duct Traverse:

1. System zone/branch/location.
2. Duct size.
3. Free area.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Duct static pressure.
7. Air temperature.
8. Air correction factor.

F. Air Terminal (Inlet or Outlet):

1. Drawing symbol.
2. Room number/location.
3. Terminal type and size.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Percent of design flow rate.

G. Air Contaminant Flushout

1. The Subcontractor shall perform a building flushout of air contaminants. The flushout must follow procedure as outlined below. The Subcontractor shall coordinate with all other trades, the General Subcontractor and Fermilab to determine the time required and scheduling for the flushout. The Subcontractor shall keep records documenting the flushout process and submit them to Fermilab when the process is complete.

   a. Pre-Occupancy Flushout: After construction is complete and prior to occupancy and with all interior finishes installed, install new filtration media and perform a flushout by supplying a total air volume of 14,000 cubic feet. of outdoor air per square foot of floor area while maintaining an internal temperature of at least 60°F and relative humidity no higher than 60%.

END OF SECTION 15990

SECTION 15995 - COMMISSIONING OF MECHANICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Responsibilities
C. Related Work
D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 15 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to specification section 01810.

C. Commissioning requires the participation of Division 15 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01810. Division 15 Contractor shall be familiar with all parts of Section 01810 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of specification section 01810.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section.

1. Commissioning Plan (Cx Plan)
2. Section 15780 - Packaged Rooftop Air Conditioning Units
3. Section 15835 - Terminal Heat Transfer Units
4. Section 15865 - Axial Fans
5. Section 15870 - Power Ventilators
6. Section 15952 - Controls
7. Section 15990 - Testing, Adjusting and Balancing
8. Section 16995 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.

2. Infrared thermometer gun.

3. Analog differential pressure gauge and associated tubing.

4. Portable computer with access to the Building Automation System.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of +/- 0.1°F.

2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01810 for additional Division 15 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of specification section 01810.

END OF SECTION 15995

SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 16 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Fire Alarm Section 16721 and Air Sampling Smoke Detection System Section 16722.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in each specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Subcontractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make his portion of the Electrical Work a finished and working system.

C. Description of Systems shall be as follows:

1. Electrical power system to and including light fixtures, equipment, motors, devices, etc.

2. Grounding system.

3. Fire alarm system.

4. Emergency power distribution system.

5. Wiring of equipment furnished by others.

1.3 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, AND CONTROL SUBCONTRACTORS

A. Division of work is the responsibility of the Prime Subcontractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Subcontractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Subcontractors" refers to the Subcontractors listed in Division 15of this Specification.

2. “Technology Subcontractors” refers to the Subcontractors furnishing and installing systems listed in Division 17 of this Specification.

3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.

4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.

5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.

7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.

8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

9. Low Voltage Technology Wiring: The wiring associated with the Technology Systems, used for analog or digital signals between equipment.

10. Telecommunications Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Subcontractors' responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the

electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Subcontractor.

2. Where the drawings require the Electrical Subcontractor to wire between equipment furnished by the Mechanical Subcontractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Subcontractor shall furnish complete wiring diagrams and supervision to the Electrical Subcontractor and designate the terminal numbers for correct wiring.

3. The Electrical Subcontractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Subcontractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity flow piping, including steam and condensate.
   c. Sheet metal.
   d. Other piping.
   e. Conduits and wireway.

D. Mechanical Subcontractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Subcontractor.

2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Subcontractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Subcontractor.

3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Subcontractor is a Subcontractor to the Mechanical Subcontractor.

4. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

E. Electrical Subcontractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Subcontractor in the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Subcontractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.

4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.

5. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5” and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5” and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The subcontractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One subcontractor shall be designated as the Coordinating Subcontractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Subcontractor for this project shall be the Mechanical Subcontractor.

   a. The Coordinating Subcontractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all subcontractors participating in the coordination process and Fermilab.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1 '-0" (minimum).

      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by Fermilab are acceptable.

2. All subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

B. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. If the information requested includes floor plans prepared by others, the Subcontractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

5. The drawings prepared for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

6. The use of these CAD documents by the Subcontractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

C. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.6 SUBMITTALS

A. Refer to Division 1 for submittal requirements.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING AND MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Subcontractor and/or Fermilab. If the Electrical Subcontractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Subcontractor is responsible for moving equipment into the building and/or site. Subcontractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Subcontractor shall

coordinate his/her work with other trades.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. The following must be submitted before final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including reproducible drawings and specifications.

3. A report documenting the instructions given to Fermilab's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Subcontractor and shall be signed by the Fermilab 's representatives.

4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Fermilab.

5. Inspection and testing report by the fire alarm system manufacturer.

6. Start-up reports on all equipment requiring a factory installation or start-up.

3.2 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for review and approval. The electronic copy shall be corrected as required to address the Fermilab's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by Fermilab.

2. Approved O&M manuals shall be completed and in the Fermilab's possession prior to Fermilab's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Submit the O&M manual.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div23.subcontractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div23.subcontractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide the Fermilab with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Fermilab, Subcontractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Fermilab’s shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copies of all factory inspections and/or equipment startup reports.

5. Copies of warranties.

6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

7. Dimensional drawings of equipment.

8. Detailed parts lists with lists of suppliers.

9. Operating procedures for each system.

10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

11. Repair procedures for major components.

12. Replacement parts and service material requirements for each system and the frequency of service required.

13. Instruction books, cards, and manuals furnished with the equipment.

14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.

3.3 INSTRUCTING FERMILAB'S REPRESENTATIVE

A. Adequately instruct the Fermilab's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Fermilab's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Fermilab has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

E. Notify Fermilab of the time and place for the verbal instructions to the Fermilab's representative so his representative can be present if desired.

F. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

G. Operating Instructions:

1. Subcontractor is responsible for all instructions to the Fermilab's representatives for the electrical and specialized systems.

2. If the Subcontractor does not have staff that can adequately provide the required

instructions, he shall include in his bid an adequate amount to reimburse Fermilab for Fermilab to perform these services.

3.4 RECORD DOCUMENTS

A. The following paragraphs supplement the requirements of Division 1.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable.

D. Record changes daily and keep the marked drawings available for Fermilab 's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to Fermilab.

3.5 PAINTING

A. Paint all equipment that is marred or damaged prior to Fermilab's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

C. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with Fermilab color preference before ordering.

3.6 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Fermilab's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.7 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with Fermilab's representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with Fermilab's representative will result in removal and reinstallation of the equipment at the Subcontractor's expense.

3.8 SYSTEM COMMISSIONING

A. The electrical systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Subcontractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

1. The Subcontractor and equipment suppliers shall have skilled technicians to ensure that all systems perform properly.

3.9 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction.

2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.

3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.

4. Any wiring device, electrical apparatus or lighting fixture, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.

B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to Fermilab a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)

2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain. Ground resistance values shall be verified by Fermi Lab at the time the readings are taken.

3. If the ground resistance value obtained is more than the value set forth in Section 16450, thefollowing shall be done to obtain the value given:

   a. Verify that all connections in the service ground system are secure.

   b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.

   c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.

   d. Review results with Fermilab.

4. Before final payment is made to the Subcontractor submit a written report to Fermilab including the following:

   a. Date of test.

   b. Number of hours since the last rain.

   c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.

   d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.

   e. Make, model, and calibration date of test equipment.

   f. Tabulation of measurements taken and calculations made.

C. Other Equipment:

1. Give other equipment furnished and installed by the Subcontractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

D. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as Fermilab or authority having jurisdiction deem necessary.

END OF SECTION 16010

SECTION 16016 - POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Low voltage distribution system power study.
B. Short-circuit analysis and report.
C. Selective coordination analysis and report.
D. Arc-flash hazard analysis and report.

1.2 SUBMITTALS

A. Analyses shall be performed by an agent authorized by the manufacturer of equipment specified in the related specification sections and shall bear the seal/signature of the licensed Professional Engineer who performed the analysis.

B. The input for the power system study shall be based on the contract documents, with estimated conductor lengths provided by the Electrical Subcontractor.

C. Documentation of the analyses shall accompany the shop drawing submittals for equipment provided under the related work specification sections. These shop drawings will not be reviewed without this documentation.

D. Power system study project model shall be submitted on electronic media for review and the Fermilab's operating and maintenance records.

1.3 SCOPE

A. Provide a power system study of the electrical system shown on the plans. The study shall include arc-fault analysis, selective coordination analysis and arc flash hazard analysis.

B. Subcontractor is required to provide a fully coordinated system for the normal and emergency electrical system and all other locations indicated on the one line diagram. Subcontractor shall provide overcurrent protective devices with the appropriate models, frame sizes, trip units, etc. as required to provide a selectively coordinated system.

PART 2 - PRODUCTS

2.1 Power systems study shall be completed in Power Tools for Windows (PTW) 7.0 or later version or pre-approved equivalent program.

PART 3 - EXECUTION

3.1 SHORT-CIRCUIT ANALYSIS

A. Provide a complete short-circuit analysis from the distribution transformers to and including the entire building distribution as shown on the drawings.

B. Analysis shall include the entire distribution system from the point of connection to the distribution transformers to the distribution panels and branch circuit panelboards.

C. Documentation shall be made in one-line diagram form showing the magnitude and location of each calculated fault. Fault current calculations shall be made at the main bus of each switchboard, distribution panel, and branch circuit panel. A summary of the fault currents available shall also be submitted.

3.2 SELECTIVE COORDINATION ANALYSIS

A. Provide a complete selective coordination analysis, comparing time/current curves of the protective devices to be installed to assure complete selectivity between main and downstream devices. 1.3.B says everything should coordinate.

B. The analysis shall include primary protective device, secondary main distribution panel device(s), distribution panel branch feeder devices, generator breaker, distribution panel, panelboard main devices, and branch feeder devices.

C. The coordination plots provided shall indicate graphically the coordination proposed for the system on full-size log forms and shall define the types of protective devices selected, together with proposed time dial and pickup settings required. The plots shall include titles, representative one-line diagrams, legend, complete parameters for transformer(s), and complete operating bands for circuit breaker trip devices, fuses, etc.

1. The long-time region of the coordination plots shall designate the pickups required for the circuit breakers.

2. The short-time region shall indicate the magnetizing in-rush and ASA-withstand-transformer parameter, the circuit breaker, short-time and instantaneous trip devices, fuse-manufacturing tolerance bands, significant symmetrical fault currents, etc.

3. The protective device characteristics or operating bands shall be suitably indicated to reflect the actual symmetrical fault currents sensed by the device.

4. The drawings and specifications indicate the general requirements for motors, motor-starting equipment, and medium-voltage and low-voltage equipment, but additional specific requirements of equipment furnished shall be determined in accordance with the results of the coordination study.

a. The study shall include verification of equipment ratings and settings. The Subcontractor shall keep the study up-to-date with any project changes which affect the study and submit the revised study for review. A final electronic copy shall be submitted with the record drawings.

D. Provide summary table of adjustable overcurrent protective devices settings for the operating and maintenance manual.

3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, unit substations, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. Safe working distances shall be based on the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared, and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3 to 5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible

(e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

G. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

H. When performing incident energy calculations on the line side of a main breaker (as required per the above), the line side and load side contributions must be included in the fault calculation.

I. Mis-coordination should be checked among all devices within the branch containing the immediate protective device upstream of the calculation location, and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

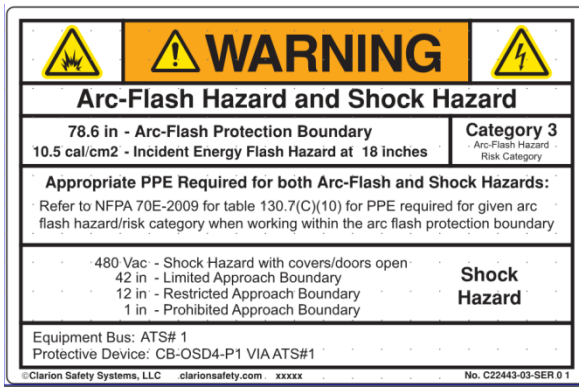
J. Arc flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section.

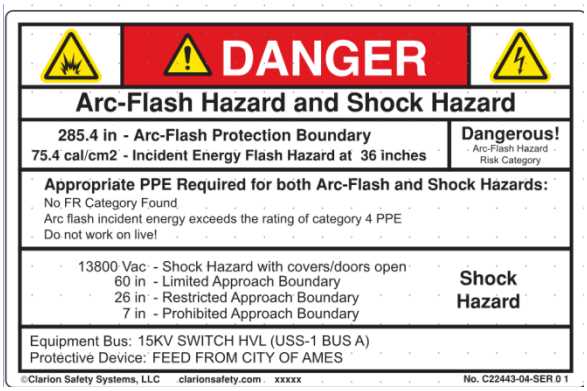
K. Where it is not physically possible to move outside the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

L. Create and install NFPA 70E compliant labels describing the arc flash hazard level at all switchboards, panelboards, and other locations in the electrical distribution system where work could be performed on energized parts.

M. The label shall include the incident energy calculated in the analysis and the hazard category or appropriate personal protective equipment (PPE) required to perform maintenance on the system when energized. Labels shall be vinyl or laminated, with a self-adhesive backing. Submit a sample label for Fermilab review and approval prior to printing.

N. Examples showing the minimum required information follow:





O. A list of all hazard categories and the corresponding PPE requirements shall be posted in the main electric room, engineering office, or other location. The list

shall be plastic laminate or typewritten and housed in a plastic frame.

3.4 ADJUSTMENTS

A. Manufacturer's authorized representative or Subcontractor shall set all adjustable protective devices to values indicated in the approved coordination study.

3.5 TRAINING

A. Provide four hours of Fermilab training to explain the implications of arc-flash requirements and work permit procedure.

END OF SECTION 16016

SECTION 16080 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 723 - Surface Burning Characteristics of Building Materials
B. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops
C. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)
D. Warnock Hersey - Directory of Listed Products
E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
F. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops
G. 2006 International Building Code
H. NFPA 5000 – Building Construction Safety Code

1.4 SUBMITTALS

A. Submit under provisions of Division 1.

B. Submit Firestopping Installers Certification for all installers on the project.

C. Shop Drawings: Submit for each condition requiring firestopping. Include descriptions of the specific penetrating item, actual wall/floor construction, manufacturer's installation instructions, and UL or Warnock Hersey Assembly number.

D. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F and T ratings for each firestop system.

E. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall

be made available to the Authority Having Jurisdiction at their request and turned over to Fermilab at the end of construction as part of the O&M Manuals.

F. Submit VOC rating of firestopping material in g/L (less water) with documentation that it meets the limits set forth in SCAQMD Rule 1168.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.6 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings**:**

a. Floor penetrations located outside wall cavities.
b. Floor penetrations located outside fire-resistance-rated shaft enclosures.
c. Wall penetrations above corridor ceilings which are not part of a fire-resistive assembly.
d. Wall penetrations below any ceiling that are larger than 4" diameter or 16 square inches.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

F. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

1.7 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and Fermilab.

1. Review foreseeable methods related to firestopping work.

2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.8 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Produces Division.
2. Hilti, Inc.
3. RectorSeal Corporation, Metacaulk.

4. Tremco; Sealant/Weatherproofing Division.
5. Johns-Manville.
6. Specified Technologies Inc. (S.T.I.)
7. Spec Seal Firestop Products
8. AD Firebarrier Protection Systems
9. Wiremold/legrand: FlameStopper

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Firestopping systems for plumbing and wet pipe sprinkler piping shall be moisture resistant.

E. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

F. Provide firestopping systems allowing continuous insulation for all insulated pipes.

G. Provide firestopping systems classified by UL or listed by Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated
   F Rating = Floor/Wall Rating
   T Rating = Floor/Wall Rating

Penetrating Item	UL System No.
No Penetrating Item	FC 0000-0999*
Metallic Pipe or Conduit	FC 1000-1999
Non-Metallic Pipe or Conduit	FC 2000-2999
Electrical Cables	FC 3000-3999
Cable Trays	FC 4000-4999
Insulated Pipes	FC 5000-5999
Bus Duct and Misc. Electrical	FC 6000-6999
Duct without Damper and Misc. Mechanical	FC 7000-7999
Multiple Penetrations	FC 8000-8999

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated
F Rating = Wall Rating
T Rating = 0

Penetrating Item	UL System No.
No Penetrating Item	WL 0000-0999*
Metallic Pipe or Conduit	WL 1000-1999
Non-Metallic Pipe or Conduit	WL 2000-2999
Electrical Cables	WL 3000-3999
Cable Trays	WL 4000-4999
Insulated Pipes	WL 5000-5999
Bus Duct and Misc. Electrical	WL 6000-6999
Duct without Damper and Misc. Mechanical	WL 7000-7999
Multiple Penetrations	WL 8000-8999

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated
F Rating = Wall/Floor Rating
T Rating (Floors) = Floor Rating

Penetrating Item	UL System No.
No Penetrating Item	CAJ 0000-0999*
Metallic Pipe or Conduit	CAJ 1000-1999
Non-Metallic Pipe or Conduit	CAJ 2000-2999
Electrical Cables	CAJ 3000-3999
Cable Trays	CAJ 4000-4999
Insulated Pipes	CAJ 5000-5999
Bus Duct and Misc. Electrical	CAJ 6000-6999
Duct without Damper and Misc. Mechanical	CAJ 7000-7999
Multiple Penetrations	CAJ 8000-8999

*Alternate method of firestopping is patching opening to match original rated construction.

H. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

I. Any openings in floors or walls not described in the UL or listed by Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Fermilab, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 IDENTIFICATION

A. Provide and install labels adjacent to each firestopping location. Label shall be provided by the firestop system supplier and contain the following information in a contrasting color:

1. The words "Warning - Through Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."

2. Firestop System Supplier; UL or listed by Warnock Hersey system number; date installed; subcontractor name and phone number; manufacturer's representative name, address, and phone number.

3.5 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by Fermilab at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

END OF SECTION 16080

SECTION 16111 - CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings
B. Intermediate metallic conduit and fittings
C. Electrical metallic tubing and fittings
D. Flexible metallic conduit and fittings
E. Liquidtight flexible metallic conduit and fittings
F. Rigid polyvinyl chloride conduit and fittings
G. Wall and ceiling outlet boxes
H. Electrical connection
I. Pull and junction boxes

1.2 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
4. ANSI C80.6 – Intermediate Metal Conduit, Zinc Coated
5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports

B. NECA “Standards of Installation”

C. National Electrical Manufacturers Association (NEMA):

1. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
2. RN 1 – Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
3. TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
4. TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation

D. National Fire Protection Association (NFPA):

1. ANSI/NFPA 70 – National Electrical Code

E. Underwriters Laboratories (UL): Applicable Listings

1. UL 1 – Flexible Metal Conduit
2. UL 6 – Rigid Metal Conduit
3. UL 360 – Liquid Tight Flexible Steel Conduit
4. UL514-B – Conduit Tubing and Cable Fittings
5. UL651-A – Type EB and a PVC Conduit and HDPE Conduit
6. UL651-B – Continuous Length HDPE Conduit
7. UL746A – Standard for Polymeric Materials – Short Term Property Evaluations

8. UL797 – Electrical Metal Tubing
9. UL1242 – Intermediate Metal Conduit

F. Definitions:

1. Fittings: Conduit connection or coupling.

2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.

3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.

4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.

5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.

6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.

7. Slab: Horizontal pour of concrete used for the purpose of a floor or sub-floor.

1.3 SUBMITTALS

A. Include conduits 1.5” and larger in coordination files. Include all in--floor and underfloor conduit in coordination files. Refer to Section 16010 for coordination drawing requirements.

B. Provide product submittals to Fermilab, per specifications, on floor boxes and slip sleeves for approval prior to purchase and installation.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Acceptable Manufacturers:

1. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

2. Acceptable Manufacturers of RMC Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, Crouse-Hinds, Killark, or approved equal.

B. Minimum Size Galvanized Steel: 3/4 inch (19mm), unless otherwise noted.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

D. PVC Externally Coated Conduit: NEMA RN 1; rigid steel conduit with external 20 mil PVC coating and internal galvanized surface. All fittings and conduit bodies shall be complete with coating. Acceptable Manufacturers: Robroy, Permacote, or approved equal.

2.2 INTERMEDIATE METALLIC CONDUIT (IMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor

saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers of EMT Conduit: Allied, LTV, Steelduct, Wheatland Tube Co, or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression type of steel designed for their specific application.

2. Larger than 2": Compression type of steel designed for their specific application.

3. Acceptable Manufacturers of EMT Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, or approved equal.

2.4 FLEXIBLE METALLIC CONDUIT (FMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire may be a manufactured, UL listed 3/8” flexible metal conduit with #12 AWG THHN conductors and an insulated ground wire.

B. Acceptable Manufacturers: American Flex, Alflex, Electri-Flex Co, or approved equal.

C. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Provide a separate equipment grounding conductor when used for equipment where flexibility is required.

D. Fittings and Conduit Bodies:

1. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron or screw-in type, die-cast zinc.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: O-Z/Gedney Co., Thomas & Betts, Appleton Electric, Electroline, Bridgeport, Midwest, Regal, or approved equal.

2.5 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Acceptable Manufacturers: Anaconda Type UA, Electri-Flex Type LA, Alflex, Carlon (Lamson & Sessions), or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:

1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: Appleton Electric, O-Z/Gedney Co., Electroline, Bridgeport, Thomas & Betts, Midwest, Regal, Carlon (Lamson & Sessions), or approved equal.

2.6 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or approved equal.

C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

2.7 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, minimum of 14 gauge, with 1/2 inch male fixture studs where required.

B. Cast Boxes: NEMA FB1, Type FD, Aluminum or cast feralloy, deep type, gasketed cover, threaded hubs.

C. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

D. Switch outlet boxes for local light control switches shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to

the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

E. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.8 ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per NEC. Coordinate requirements with subcontractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.9 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

PART 3 - EXECUTION

3.1 CONDUIT SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to N.E.C. (Latest Edition). Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the National Electrical Code (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. <u>Minimum</u> Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)

2. Below Grade 5' or less from Building Foundation: 1 inch.

3. Below Grade More than 5' from Building Foundation: 1 inch.

4. Telecommunication Conduit: 1 inch.

5. Controls Conduit: 3/4 inch.

C. Maximum Conduit Size Embedded in Slabs above Grade: 3/4 inch for conduits crossing each other.

D. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Conduit shall not share the same cell as structural reinforcement in masonry walls.

C. Conduit runs shall be routed as shown on large scale drawings. Conduit routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Subcontractor based on information in the contract documents, in accordance with manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", in accordance with recognized industry standards, and coordinated with other subcontractors.

D. Subcontractor shall adapt his work to the job conditions and make such changes as required and permitted by Fermilab, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

E. Subcontractor shall cooperate with all Subcontractors on the project. He shall obtain details of other Subcontractor's work in order to ensure fit and avoid conflict. Any expense due to the failure of This Subcontractor to do so shall be paid for in full by him. The other trades involved as directed by Fermilab shall perform the repair of work damaged as a result of neglect or error by This Subcontractor. The resultant costs shall be borne by This Subcontractor.

3.3 CONDUIT SUPPORT

A. Conduit runs shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.

B. Conduit shall not be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by Fermilab. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable subcontractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1-1/2" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Intervals between supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the National Electrical Code requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

L. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1” of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6’-6” of finish floor and presents potential injury to personnel.

3.4 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.

2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.

3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will <u>not</u> be permitted.

4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.

2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).

3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.

4. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.

5. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to

all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the National Electrical Code.

2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.

3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.

4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5” below bottom of roof decking.

5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.

6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal. Refer to Section 16080.

7. Conduits that must pass through footers or foundation walls must pass through a reinforced opening coordinated in advance and formed at the time the footer or foundation is constructed.

8. SUBCONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS SUBCONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.

9. Seal interior of conduit at exterior entries, air handling units, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, equal to O-Z/Gedney type EYD.

10. Conduits, if run in concrete structure, shall be in middle one-third of slab thickness, and leave at least 3” min. concrete cover. Conduits shall run parallel to each other and spaced at least 8” apart centerline to centerline. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Maximum conduit outside diameter 1”.

11. No conduits are allowed in concrete on metal deck unless expressly approved in writing by the Structural Engineer.

12. Do not route conduits across each other in slabs on grade.

13. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.

14. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

15. Conduits that cross structural expansion joints or transition from underground to building structure shall be provided with an expansion deflection coupling. PVC conduit runs that do not have bends that will accommodate thermal expansion and contraction shall have expansion couplings. Temperature at time of installation of expansion couplings shall be carefully considered against expected temperature range when adjusting installed length of the coupling.

16. Subcontractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.

17. Subcontractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.

18. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3” above finished floor (AFF).

19. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4” below ceiling and as close to the wall as possible.

20. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4” above finished floor (AFF) and as close to the wall as possible.

3.5 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, or approved equal.

B. Conduits without termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.

C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6’ in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer’s recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of any and all foreign matter prior to any wires or pull cords being installed.

3.6 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.

2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2” and ten times the diameter for conduits over 2”. Where long cable runs are involved, sidewall pressures may require larger radius bends. Provide pulling tension calibrations to Fermilab prior to conduit installation to determine bend radius for all duct over 100 feet long or containing over 180°F of bends.

C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (>600V) and 18 inches for secondary conduits (<600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.

2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.

3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used. Dust top of freshly placed duct bank concrete with red dye.

4. Before the Subcontractor pulls any cables into the conduit he shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Subcontractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.

5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.

6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.

7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications or to achieve proper drainage.

8. All non-metallic conduit installed underground outside of a slab shall be rigid schedule 40 or 80.

E. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceways shall also be sealed.

2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with

"JackMoon" or equivalent duct seal, capable of withstanding a 10 foot head of water (5 PSI).

3.7 CONDUIT INSTALLATION SCHEDULE

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from Fermilab. If This Subcontractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the National Electrical Code shall be required.

B. The following schedule shall be adhered to unless they constitute a violation of applicable codes or are noted otherwise on the drawings. The installation of RMC conduit will be permitted in place of any and all conduit specified in this schedule.

1. Interior Locations:

   a. Distribution panel, panel feeders, etc.: IMC.

   b. Branch Circuits (lighting, receptacles, controls, etc.): EMT.

   c. Mechanical Equipment Feeders (pumps, AHU's, chillers, etc.): EMT.

   d. Floor Mounted Pump Feeders: EMT with no more than 6' of PVC coated flexible metal conduit to pump.

   e. Controls: EMT painted blue or dyed blue.

2. Wet or Damp Locations: RMC conduit, boxes and fittings, installed and equipped so as to prevent water from entering the conduit system.

3. In or Under Slabs on Grade or Site Conduits:

   a. Within 5' from the Exterior Perimeter of a Building Foundation: Concrete encased PVC conduit with a minimum of 3" thickness between the surface of the concrete and the nearest conduit. Concrete to be doweled into the foundation.

   b. 5' or Greater from the Exterior Perimeter of a Building Foundation: PVC unless noted otherwise on the drawings.

   c. Under Roads, Drives, and Vehicle Traveled Ways: Concrete encased PVC with a minimum of 3" concrete cover on all sides of conduit.

4. Hazardous Locations as Defined by the National Electrical Code: RMC conduit complete with screwed fittings and conduit seals.

3.8 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

1. Concealed interior locations above ceilings and in hollow studded partitions.
2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8’ above the highest platform level.
3. Direct contact with concrete except slab on grade.

B. Cast boxes shall be used in:

1. Exterior locations.
2. Hazardous locations.
3. Exposed interior locations within 8’ of the highest platform level.
4. Direct contact with earth.
5. Direct contact with concrete in slab on grade.
6. Wet locations.

3.9 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with Fermilab and Subcontractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Subcontractor to avoid radiant cabinets.

3.10 OUTLET BOX INSTALLATION

A. The Subcontractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Subcontractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

B. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

C. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

D. Provide knockout closures for unused openings.

E. Support boxes independently of conduit.

F. Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

G. Install boxes in walls without damaging wall insulation.

H. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

I. Position outlets to locate luminaires as shown on reflected ceiling drawings.

J. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

K. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

L. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.11 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

3.12 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)

F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION

SECTION 16120 - WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire
B. Remote control and signal cable

1.2 REFERENCES

A. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy

B. UL 44 – Thermoset-Insulated Wires and Cables

C. UL 83 – Thermoplastic-Insulated Wires and Cables

D. UL 854 – Service-Entrance Cables

E. UL 1581 – Standard for Electrical Wires, Cables, and Flexible Cords

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits Larger Than 6 AWG: Copper, stranded conductor, 600 volt insulation, THHN/THWN.

B. Feeders and Branch Circuits Larger than 6 AWG in Underground Conduit: Copper, stranded conductor, 600 volt insulation, THWN.

C. Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600 volt insulation, THHN/THWN. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, solid or stranded conductor, unless otherwise noted on the drawings.

D. Control Circuits: Copper, stranded conductor 600 volt insulation, THHN/THWN.

E. Each 120 and 277 volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600 volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings: Building wire in raceways.

B. All Other Locations: Building wire in raceway.

C. Above Grade: All conductors installed above grade shall be type “THHN”.

D. Underground or In Slab: All conductors shall be type “THWN”.

3.2 WIRE FOR SPECIALIZED SYSTEMS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed:

1. Fire alarm
2. Low voltage switching

3.3 SUBCONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, NEC Table 310.16. Service entrance conductors are based on copper conductor installed in underground electrical ducts, NEC Table B.310.15(B)(2)(7).

B. The Subcontractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Underground electrical duct ampacity rating shall be in accordance with NEC Table B.310.15(B)(2)(7) or calculated in accordance with Annex B Application Information for Ampacity Calculation. The calculations and a sketch of the proposed installation shall be submitted prior to any conduit being installed.

D. Record drawing shall include the calculations and sketches.

3.4 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring (<100 volts).

C. Use 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet.

D. Use no wire smaller than 8 AWG for outdoor lighting circuits.

E. The ampacity of multiple conductors in one conduit shall be derated per National Electrical Code, Article 310. In no case shall more than 4 current carrying conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

F. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

G. Splice only in junction or outlet boxes.

H. Neatly train and lace wiring inside boxes, equipment, and panelboards.

I. Make conductor lengths for parallel circuits equal.

J. All conductors shall be continuous in conduit from last outlet to their termination.

K. Terminate all spare conductors on terminal blocks, and label the spare conductors.

L. Cables or wires shall not be laid out on the ground before pulling.

M. Cables or wires shall not be dragged over earth or paving.

N. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

O. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

P. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.5 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially thru raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.

F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:

1. Support conductors in vertical raceways in accordance with NEC 300.19 and Table 300.19(A) Spacing of Conductors Supports.

2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.6 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for copper conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use copper, compression connectors applied with circumferential crimp for copper wire splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. Unless extenuating circumstances require, and only with prior approval by Fermilab connections to switches, circuit breakers, starters, panelboards, switchgear and the like, arrangement phase conductors shall be:

1. Facing the <u>front and operating</u> side of the equipment, the phase identification shall be:

a. Left to Right - A-B-C
b. Top to Bottom - A-B-C

J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

3.7 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Refer to Section 16950.

C. Inspect wire and cable for physical damage and proper connection.

D. Torque test conductor connections and terminations to manufacturer's recommended values.

E. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

END OF SECTION 16120

SECTION 16141 - WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Device plates and box covers
B. Receptacles including GFCI and/or weather resistant

1.2 QUALITY ASSURANCE

A. Provide similar devices from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency to Authorities Having Jurisdiction and marked for intended use.

C. Comply with NFPA 70.

1.3 REFERENCES

A. DSCC W-C-896F – General Specification for Electrical Power Connector

B. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet

C. FS W-S-896 - Switch, Toggle

D. NEMA WD 1 – General Color Requirements for Wiring Devices

E. NEMA WD 6 – Wiring Devices – Dimensional Requirements

F. UL 498 – Standard for Attachment Plugs and Receptacles

G. UL 943 – Standard for Ground Fault Circuit Interrupters

1.4 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

1.5 COORDINATION

A. Receptacles for Fermilab Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 DEVICE COLOR

A. All switch, receptacle, outlet, and coverplate colors shall be verified with Fermilab,

unless indicated otherwise.

2.2 COVERPLATES

A. All switches, receptacles, and outlets shall be complete with the following:

1. #302 stainless steel coverplates in finished spaces where wall are finished.

2. #302 stainless steel coverplates in unfinished spaces for flush boxes.

3. Galvanized steel coverplates in unfinished spaces for surface mounted boxes.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 16195.

D. Plate securing screws shall be metal with head color matching the wall plate finish.

2.3 RECEPTACLES

A. Refer to Electrical Symbols List for device type.

B. Devices that are shaded on the drawings shall be red.

C. NEMA 5-20R Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face and brass back strap.

D. NEMA 5-20R Ground Fault Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face.

E. NEMA 5-20R Weatherproof Ground Fault Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face. Provide NEMA 3R rated while-in-use cast aluminum cover.

F. Back wired devices shall be complete with eight holes that are screw activated with metal clamps for connection to #12 or #10 copper conductors.

G. Side wired devices shall have four binding screws that are undercut for positive wire retention.

H. Ground Fault Circuit Interrupter (GFCI) receptacles shall comply with the 2006 edition of U.L. 943 requiring increased surge immunity, improved corrosion

resistance, improved resistance to false tripping and diagnostic indication for miswiring if the line and load conductors are reversed during installation.

I. Industrial heavy-duty pin and sleeve devices shall comply with IEC 309-1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install light convenience receptacles at elevations indicated in the General Installation Notes on the contract drawings.

B. Install specific-use receptacles at heights shown on the contract drawings. Install devices level, plumb, and square with building lines. Coordinate installation of adjacent devices of separate systems with common mounting heights, including lighting, power, systems, technology, and temperature control device rough-ins.

C. Install receptacles vertically with ground slot up or where indicated on the drawings, horizontally with ground slot to the left.

D. Install decorative plates on switch, receptacle, and blank outlets in finished areas, using jumbo size plates for outlets installed in masonry walls.

E. Install devices and wall plates flush and level.

F. Install nameplate identification to receptacle cover plates. Identification shall identify panel name and circuit number. Refer to Specification Section 16195 - Electrical Identification.

G. Test receptacles for proper polarity, ground continuity and compliance with requirements.

END OF SECTION 16141

SECTION 16190 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and equipment supports
B. Fastening hardware

1.2 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

1.3 COORDINATION

A. Coordinate size, shape and location of concrete pads with Section on Cast-in-Place Concrete or Concrete Topping.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Allied Support Systems
B. Cooper B-Line
C. Erico, Inc.
D. Hilti
E. Power Fasteners

2.2 MATERIAL

A. Support Channel: Hot-dip galvanized. All field cut ends shall be touched up with matching finish to inhibit rusting.

B. Hardware: Corrosion resistant.

C. Anchorage and Structural Attachment Components:

1. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to Authorities Having Jurisdiction.

a. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

2. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

3. Welding Lugs: Comply with MSS-SP-69, Type 57.

4. Beam clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

5. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

7. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-08. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

8. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

D. Conduit Sleeves and Lintels:

1. Each Subcontractor shall provide, to the Subcontractor for installation, lintels for all openings required for the Subcontractor's work in masonry walls and conduit sleeves for floors, unless specifically shown as being by others.

2. Refer to Structural plans and specifications for lintel requirements and sizes.

3. Fabricate all lintels from structural steel shapes or as indicated on the drawings. All lintels and grouped wall openings shall be approved by Fermilab.

4. Fabricate all sleeves from standard weight black steel pipe. Provide continuous sleeve. Cut or split sleeves are not acceptable.

5. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

6. Sleeves shall not penetrate structural members without approval from Fermilab.

7. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

8. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Subcontractor is responsible for sleeves dislodged or

moved when pouring concrete.

9. Where conduits rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

10. Size sleeves large enough to allow expansion and contraction movement.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors in concrete and beam clamps on structural steel.

B. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

C. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment, or conduit, unless otherwise noted.

D. Do not use powder-actuated anchors without specific permission.

E. Do not drill structural steel members.

F. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

G. In wet locations and on all building floors below exterior earth grade install free-standing electrical equipment on concrete pads.

H. Install cabinets and panelboards with minimum of four anchors. Provide horizontal backing/support framing in stud walls for rigid mounting. Provide steel channel supports to stand surface-mounted panelboard or cabinet one inch off wall.

I. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

J. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

K. Refer to Section 16111 for special conduit supporting requirements.

3.2 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

B. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1” of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6’-6” of finish floor and presents potential injury to personnel.

END OF SECTION 16190

SECTION 16195 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Nameplates and tape labels
B. Wire and cable markers
C. Conduit color coding
D. Conductor color coding
E. Electrical gear labeling
F. Power distribution equipment labeling
G. Transformer equipment labeling

1.2 REFERENCES

A. ANSI C2 – National Electrical Safety Code

B. NFPA 70 – National Electrical Code

C. ANSI A13.1 – Standard for Pipe Identification

D. ANSI Z535.4 – Standard for Product Safety Signs and Labels

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

A. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

B. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Cable Identification: flexible acrylic bands sized to suit the cable diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the cable.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

D. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

E. Underground Plastic Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inches wide by 4 mil thick, printed legend indicating type of underground line, manufactured for direct burial service. Tape shall contain a continuous metallic wire to allow location with a metal detector.

F. Aluminum, Wraparound Marker Bands: 1" in width, .014 inch thick aluminum bands with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

G. Brass or aluminum Tags: 2" by 2" by .05-inch metal tags with stamped legend, punched for fastener.

H. Indoor/Outdoor Number and Letters: Outdoor grade vinyl label, minimum of 3/4” high x 9/16” wide, with acrylic adhesive designed for permanent application in severe indoor and outdoor environments.

2.2 NAMEPLATES AND SIGNS

A. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Labels shall be punched for mechanical fasteners. Engraving legend shall be as follows:

1. Black letters on white face for normal power.

2. White letters on red face for emergency power.

3. White letters on green face for grounding.

4. Black letter on yellow face for Caution or UPS.

B. Baked–Enamel Signs for interior Use: Preprinted aluminum signs, punched, or drilled for fasteners, with colors, legend, and size required for application. Mounting ¼" grommets in corners.

C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with .0396 inch galvanized-steel backing: and with colors, legend, and size required for application. Mounting ¼" grommets in corners.

D. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

E. Fasteners for Plastic-Laminated Signs; Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer’s written instruction and requirements of NEC.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. All mounting surfaces shall be cleaned and degreased prior to identification installation.

D. Identify Junction, Pull and Connection Boxes: Labeling shall be 3/8-inch Kroy tape or Brother self-laminating vinyl label, color-coded same as conduits or permanent magic marker (color coded), neatly hand printed. In rooms that are painted out, provide labeling on inside of cover.

E. Circuit Identification: Tag or label conductors as follows:

1. Multiple Power or Lighting Circuits in Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.

2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

F. Apply warning, caution and instruction signs as follows:

1. Install warning, caution or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operating Signs: Install, where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

G. Apply circuit/control/item designation labels of engraved plastic laminate for pushbuttons, pilot lights, alarm/signal components, and similar items, except where labeling is specified elsewhere.

H. Install labels parallel to equipment lines at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

I. Install ARC FLASH WARNING signs on all switchboards, panelboards, industrial control panels, and motor control centers. Refer to 16016.

J. Circuits with more than 600V: Identify raceway and cable with "DANGER—HIGH VOLTAGE" in black letters 2 inches high on orange background at 10'-0 foot intervals.

1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to conduits concealed within wall.

3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.

K. Underground Electrical Lines: For exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single marker.

3.2 SWITCH AND RECEPTACLE COVER PLATES

A. Provide identification on all switch and receptacle cover plates. Identification shall indicate source and circuit number serving the device (i.e. “C1A #24”).

B. Identification material to be a clear, 3/8-inch Kroy tape or Brother self-laminating vinyl label with black letters in normal size “Swiss 721 Bold” font. Letter and number size to 3/16-inch high. Embossed Dymo-Tape labels are not acceptable. Permanently affix identification label to cover plates, centered above the receptacle openings.

C. Identification to be engraved directly on the stainless steel coverplates. Letter and number size to 1/8-inch high.

D. Provide identification inside all switch and receptacle backboxes. Identification shall be neatly hand written in permanent magic marker and shall indicate source and circuit number serving the device (i.e. “C1A#24”).

3.3 BOX LABELING

A. All junction, pull, and connection boxes shall be identified as follows:

1. For power and lighting circuits, indicate system voltage and identity of contained circuits (“120V, 1LA1CKT3,5,7”).

2. For other wiring, indicate system type and description of wiring (“FIRE ALARM NAC #1”).

B. Box covers shall be painted to correspond with system type as follows:

1. Fire Alarm: Red.
2. Emergency: Orange.
3. Controls: Blue.
4. Normal Power Distribution System: Silver.

5. Ground: Green.

3.4 CONDUIT COLOR CODING SCHEDULE

A. Provide color coded conduit as indicated below. Conduit shall be colored by the manufacturer:

1. Fire Alarm System: Red.
2. Normal Power Distribution System: Silver.
3. Emergency Power Distribution System: Orange.
4. Ground: Green.
5. Controls: Blue.

B. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

C. This Subcontractor shall furnish and install framed 8" x 10" charts of the color coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

3.5 CONDUCTOR COLOR CODING

A. Color coding shall be applied at all panels, switches, junction boxes, pull boxes, vaults, manholes etc., where the wires and cables are visible and terminations are made. The same color coding shall be used throughout the entire electrical system, therefore maintaining proper phasing throughout the entire project.

B. Where more than one nominal voltage system exists in a building or facility, the identification of color coding used in the panelboard or equipment shall be permanently posted on the interior of the door or cover.

C. All wires and cables used in motor circuits, main feeders, sub-main feeders and branch circuits, shall be coded by the application of plastic tape.

D. Wire and cables shall be color coded by the manufacturer.

E. Where more than one nominal voltage system exists in a building or facility, each ungrounded conductor of a multi-wire branch circuit, where accessible, shall be identified by phase and system.

F. Conductors shall be color coded as follows:

1. 208Y/120 Volt, 4-Wire:

a. A-Phase – Black
b. B-Phase – Red
c. C-Phase – Blue
d. Neutral – White
e. Ground Bond – Green

2. 480Y/277 Volt, 4-Wire:

a. A-Phase – Brown
b. B-Phase – Orange
c. C-Phase – Yellow
d. Neutral – Gray
e. Ground Bond – Green

3.6 ELECTRICAL GEAR LABELING

A. Exterior electrical gear shall be identified with vinyl label names and numbers to be visible on the exterior of the gear. The labels shall correspond to the 1-line nomenclature and identify each cubicle of multi-section gear.

3.7 CONTROL EQUIPMENT IDENTIFICATION

A. Provide identification on the front of all control equipment, such as disconnect switches, starters, VFDs, contactors, motor control centers, etc. Nameplate text shall be a minimum of 1/4” high.

B. Labeling shall include:

1. Equipment type and contract documents designation of equipment being served.
2. Location of equipment being served if it is not located within sight.
3. Voltage and phase of circuit(s).
4. Panel and circuit number(s) serving the equipment.

EXHAUST FAN EF-1 ("LOCATED ON ROOF")
480V, 3-PHASE
FED FROM “1HA1CKT1”

3.8 POWER DISTRIBUTION EQUIPMENT IDENTIFICATION

A. Provide identification on the front of all power distribution equipment, such as panelboards, switchboards, etc. The identification material shall be engraved plastic-laminated labels. Text height shall be as shown on details.

B. Labeling shall include:

1. Equipment type and contract documents designation of equipment.
2. Voltage of the equipment.
3. Name of the upstream equipment and location of the upstream equipment if it is not located within sight.

DISTRIBUTION PANEL DP-H1
480Y/277V
FED FROM SWITCHBOARD “SB-1”
BKR1,3,5

C. A separate nameplate for the service entrance equipment shall be labeled with the MAXIMUM AVAILABLE FAULT CURRENT and DATE of calculation given on

the one-line diagram.

D. Distribution panelboards and switchboards shall have each overcurrent protection device identified with name and location of the load being served ("AHU-1 LOCATED IN PENTHOUSE 1").

E. Branch panelboards shall be provided with typed panel schedules upon completion of the project. Existing panelboards shall have their existing panel schedules typed, with all circuit changes, additions or deletions also typed on the panel schedules. A copy of all panel schedules for the project shall be turned over as part of the O&M Manuals. Refer to Section 16010 for other requirements.

3.9 TRANSFORMER EQUIPMENT IDENTIFICATION

A. Provide identification on the front of all transformers. The identification nameplate shall be an engraved plastic-laminated label. Text shall be a minimum of 1/4" high.

B. Labeling shall include:

1. Equipment type and contract documents designation of equipment
2. Name of the upstream equipment.
3. Voltage and rating of the equipment.
4. Location of the upstream equipment if it is not located within sight.

TRANSFORMER TR-15 480V: 208Y/120V 15KVA FED FROM SWITCHBOARD "SB-1" (LOCATED IN MAIN ELECTRIC ROOM)

END OF SECTION 16195

SECTION 16412 - SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes materials and installation requirements for low voltage surge protection devices (SPD) for the protection of all AC electrical circuits. SPD equipment to be installed at designated service entrance equipment and distribution panels.

1.2 QUALITY ASSURANCE

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be “Listed by Underwriters Laboratories” to UL 1449.

B. Each unit shall be designed and manufactured by a qualified manufacturer of power conditioning equipment. The qualified manufacturer must have been engaged in the design and manufacturer of such products for a minimum of five years.

1.3 REFERENCES

A. ANSI/IEEE C62.33 – IEEE Guide on Testing of MOV components

B. ANSI/IEEE C62.35 – IEEE Guide on Testing of SAD components

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

E. ANSI/UL 1449 Third Edition (Version 3.0) - UL Standard for Safety for Surge Protective Devices

F. CBEMA – Computer Business Equipment Manufacturers Association

G. IEC 664 – International Engineering Consortium, Standard for Clamping Voltage

H. National Electrical Code 285 - Surge Protection Devices

I. NFPA 70 - National Electrical Code

J. UL 67 – Listed for Internal Panelboard Transient Voltage Surge Suppressors

K. UL 96A – Devices listed as approved for secondary surge arrestors (VZCA)

L. UL 248-1 - Fusing

M. UL 1283 – Electromagnetic Interference Filters, Fifth Edition

1.4 SUBMITTALS

A. Shop Drawings: Should include device dimensions, mounting requirements including wire size and over-current protection device rating, nameplate nomenclature, electrical ratings, short circuit current rating, and test results as indicated below under “Testing, Warranty and Life Expectancy” as provided by an independent test lab or a UL certified test lab for the category(ies) of suppression device(s) specified using the appropriate IEEE test wave. Product data sheets with installation instructions for each size and type of device are required. Shop drawings submitted without the testing data as required by section this section will be rejected.

B. Fuse information: Provide fuse information if required for operation. Include size, manufacturer, time-current chart responses to UL 1449 testing requirements, maximum surge protection capability per mode and phase as limited by the fuse, and verification of repetitive surge protection device operation without system degeneration greater than 10%.

1.5 SPARE PARTS

A. Surge Protection Modules: Furnish 1 replacement module for each type installed.

B. Fuses: Furnish to the Fermilab 3 spare fuses of each type and rating installed.

1.6 TESTING, WARRANTY AND LIFE EXPECTANCY

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.

2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit’s suppression voltage (VPR).

3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit’s survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10%.

B. Minimum Repetitive Surge Current Capacity:

1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.

2. Minimum Repetitive Surge Current Capacity Test:

a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage.

b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.

c. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival.

3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.

4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR (voltage protection rating) for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

D. Warranty: Ten (10) years. Includes workmanship, installation and programming.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. General: The unit shall provide transient voltage suppression, surge current diversion and high-frequency noise attenuation, when connected in parallel to the facilities distribution system. The unit MCOV shall not be less than 115% of the nominal system voltage. Operating frequency shall be for a 60 Hz system. The unit shall provide protection in all normal modes for "wye" and "delta" systems. The short circuit current rating shall be the larger of the listed value on the drawings or as required by the equipment protected.

2.2 RATINGS

A. Service Entrance Suppressors:

1. For 277/480 volt, 3 phase, 4 wire, type 2, category C3 unit.

a. Surge current capacity: 100,000/200,000 amps per protection mode/phase

b. Nominal Discharge Current: 20 kA.

c. Mounting: Refer to the drawings.

d. Voltage Protection Rating: Refer to requirements below.

e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

f. Disconnect: Surge-rated disconnect with 200,000 SCCR.

B. Secondary Distribution Suppressors:

1. For 277/480 volt, 3 phase, 4 wire, type 2, category B3/C1 unit.

a. Surge current capacity: 60,000/120,000 amps per protection mode/phase

b. Nominal Discharge Current (I_N): 20 kA.

c. Mounting: Refer to the drawings.

d. Voltage Protection Rating: Refer to requirements below.

e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

C. Voltage Protection Rating:

1. Protection modes and UL 1449 voltage protection rating for surge suppression units per each mode (L-N, L-L, L-G, and N-G as appropriate).

a. 277/480 Volt, 3 phase, 4 wire.1200 Volt L-N, L-G, N-G and 1800 Volt L-L

D. EMI/RFI Noise Rejection or Filtering:

1. Each unit shall include a UL1283 first order, high-frequency filter for noise filtering between 10 KHz and 100 MHz.

E. Indication:

1. Each unit shall include solid-state indicators with externally mounted LED visual status indicators that indicate on-line status of each protection mode of the unit.

2. Each unit shall include an audible alarm with silencing switch to indicate when protection has failed.

3. Provide each service entrance and secondary distribution type unit(s) with a transient counter.

F. Fuses:

1. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit.

2. Fuses shall be rated 200, 000 AIC minimum interrupting capacity.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine equipment for size and type of surge protection device to be used to ensure physical compatibility.

B. Inspect surge protection device for any signs of physical damage due to shipping or handling before installing surge protection device.

3.2 INSTALLATION

A. Mounting Location:

1. The unit shall be installed as close as practical to the panel secondary lugs in accordance with applicable national/Local Electrical Codes and the manufacturer's recommended installation instructions. Connect the unit to the panel using a conduit nipple. Mount unit directly across from the breaker or disconnect serving it.

2. If internal surge protection device is specified, device shall be installed in a barrier compartment isolated from other components.

B. Connections:

1. Conductors from the protected bus to the unit shall not be any longer than necessary avoiding unnecessary bends. The conductor leads shall be twisted together and as short as possible. Connection shall be with mechanical lugs for each phase, neutral, and ground if applicable. Subcontractor shall provide wire and circuit breakers sized per the approved manufacturer's requirements. Maximum lead length from protected bus to surge protection device shall be per manufacturer's requirements, but no greater than 5'-0".

2. The surge protection unit shall be isolatable from the electrical distribution system via 3 pole circuit breaker mounted in the switchboard/panelboard.

3. Neutral and ground shall not be bonded together at secondary panelboard locations.

C. General:

1. Check unit for proper operation of protection and indication under start-up.

2. Check unit to ensure all MOVs for each mode of protection are operational. Verify integral fuse links are operational and have not melted.

3. Surge suppression devices shall not be installed ahead of the main service disconnect(s).

4. Install fuses in all fuse holders and fused disconnects internal to the surge protection unit. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit. External fusing of the surge protection device is not allowed.

5. Coordinate location of surge protection device to allow adequate clearances for maintenance.

6. Manufacturer service phone number shall be posted on the front of the surge protection device.

END OF SECTION 16412

SECTION 16440 - DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches
B. Non-fusible switches
C. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule for rating and configuration.

1.3 REFERENCES

A. NEMA KS 1 - Enclosed Switches

1.4 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Product Data: For each type of enclosed switch, circuit breaker, accessory and component indicated, include dimensions, weights, and manufacturer's technical data on features, performance, and ratings.

C. Electrical Characteristics: For each type of enclosed switch, enclosure types, current and voltage ratings, short-circuit current ratings, UL listing for series rating of installed devices, features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 COORDINATION

A. Coordinate layout and installation of switches and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NON-FUSIBLE SWITCHES

A. Fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Class 'R' fuse clips only, unless indicated otherwise on the drawings. Provide with viewing window.

B. Non-fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Provide with viewing window.

C. Enclosures: Type as indicated on the disconnect schedule.

D. Accessories: As indicated on the disconnect schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on the drawings.

B. Install fuses in fusible disconnect switches.

C. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

END OF SECTION 16440

SECTION 16450 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment grounding system
B. Bonding system
C. Grounding electrode system

1.2 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 Grounding and Bonding Equipment.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 16010.

B. Product Data: For the following:

1. Ground rods.

C. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Indicate layout of ground field, location of system grounding electrode connections, and routing of grounding electrode conductor and ground ring.

1.4 SUMMARY

A. This section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 16 Section 16120 "Wire and Cable".

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. Sizes and types below are typical. Adjust to suit Project conditions and requirements.

G. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inchin diameter.

2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.

3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 incheswide and 1/16 inchthick.

4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 incheswide and 1/16 inchthick.

H. Grounding Bus:

1. Bare, annealed copper bars of rectangular cross section, with insulators. 1/4” x 2” length as shown on the drawings.

2.2 CONNECTOR PRODUCTS

A. Comply with UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Exothermic-welded type, in kit form, and selected per manufacturer’s written instructions.

C. Bolted Connectors: Bolted-pressure-type connectors.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.

PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.

2. Make connections with clean, bare metal at points of contact.

3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.

5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Structural Steel Connection: Exothermic-welded connections to structural steel. Coordinate with structure to provide physical protection.

G. Underground Connections: Exothermic-welded connections.

H. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

I. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.2 INSTALLATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Each grounding

conductor that passes through a below grade wall must be provided with a waterstop.

C. Grounding electrode conductor (GEC) shall be protected from physical damage by rigid polyvinyl chloride conduit (PVC) in exposed locations.

D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

E. In raceways, use insulated equipment grounding conductors.

F. Grounding Bus: Install as indicated, with bolted connections to form a continuous ground path.

3.3 EQUIPMENT GROUNDING SYSTEM

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits. Terminate each end on a grounding lug or bus.

3.4 BONDING SYSTEM

A. At building expansion joints, provide flexible bonding jumpers to connect to columns or beams on each side of the expansion joint.

B. Connect bonding conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

3.5 GROUNDING ELECTRODE SYSTEM

A. Ground Ring (Counterpoise):

1. Ground the steel framework of the building with a driven ground rod as shown on the drawings. Provide a grounding conductor, electrically connected to each ground rod and to each steel column, extending around the perimeter of the building.

B. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.

C. Ground Rods: As shown on the drawings.

1. Drive ground rods until tops are 12 inchesbelow finished floor or final grade, unless otherwise indicated.

2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds. Make connections without exposing steel or damaging copper coating.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond each aboveground portion of natural gas metallic piping system at equipment locations. The equipment grounding conductor may serve as the bonding means.

G. Concrete-Encased Grounding Electrode (Ufer): Install concrete-encased grounding electrode encased in at least 2 inches (50mm) of concrete horizontally within the foundation that is in contact with the earth. If concrete foundation is less than 20 feetlong, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

3.6 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

1. Measure ground resistance from system neutral connection at service entrance to convenient ground reference points using suitable ground testing equipment. Resistance shall not exceed 5 ohms.

2. Testing: Perform the following field quality-control testing:

a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.

b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.

c. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

1) Equipment Rated 500 kVA and Less: 10 ohms.
2) Equipment Rated 500 to 1000 kVA: 5 ohms.
3) Substations and Pad-Mounted Switching Equipment: 5 ohms.

d. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Fermilab promptly and include recommendations to reduce ground resistance.

END OF SECTION 16450

SECTION 16461 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Premium efficient dry type two winding transformers

1.2 REFERENCES

A. NEMA - ST 1 - Specialty Transformers

B. NEMA ST 20 - Dry Type Transformers for General Applications

C. ANSI/IEEE C57.12.01 - General Requirements for Dry Type Distribution and Power Transformers

D. ANSI/IEEE C57.12.91 - Test Code for Dry Type Distribution and Power Transformers

E. NEMA TP 1 - Guide for Determining Energy Efficiency for Distribution Transformers

F. NEMA TP 2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

G. NEMA TP 3 - Standard for the Labeling of Distribution Transformer Efficiency

1.3 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, KVA, and impedance ratings and characteristics, loss data, efficiency at 35, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 16010.

B. Store in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.

C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.1 PREMIUM EFFICIENT TRANSFORMER

A. Dry Type Transformers: K-13 rated NEMA ST 20, NEMA Premium Efficiency to comply with NEMA 10 CFR 431.196 to comply with the US Department of Energy Candidate Standard Level 3 (CLS-3); factory-assembled, air-cooled, dry type transformers; ratings as shown on the drawings.

B. Insulation system and average winding temperature rise for rated KVA as follows:

KVA Rating	Insulation Class	Temperature Rise (degree C)
10-500	220	150

C. Winding Taps, Transformers 15 KVA and Larger: 2-1/2% below and 2-1/2% above rated voltage, full capacity taps on primary winding.

D. Sound Levels: Maximum sound levels are as follows:

KVA Rating	Sound Level
15-50	42 dB
51-150	47 dB
151-300	52 dB

E. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

F. Mounting: Transformers 75 KVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 KVA shall be suitable for floor or trapeze mounting. Isolate core and coil from enclosure using vibration-absorbing mounts.

G. Coil Conductors: Continuous copper windings with terminations brazed or welded. Neutral shall be 200% rated with twice the capacity of secondary lugs.

H. Provide electrostatic winding shield with separate insulated grounding connection.

I. Enclosure: NEMA ST 20; Type 1. Provide lifting eyes or brackets.

J. Nameplate: NEMA TP 3; include transformer connection data and overload capacity based on rated allowable temperature rise.

K. Minimum efficiency (tested at 35% of the nameplate rating per NEMA TP-1, and TP-2).

2.2 ACCESSORIES

A. Electronic Isolation Shield:

1. Provide electrostatic winding shield with separate insulated grounding connection as shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on four 3”x3”x1/2” thick, 50 durometer rubber vibration isolating pads suitable for isolating the transformer noise from the building structure.

3.2 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments. Adjustments shall be made at completion of project and at approximately 6 months following project acceptance when requested by Fermilab.

END OF SECTION 16461

SECTION 16470 - PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Service and distribution panelboards
B. Lighting and appliance branch circuit panelboards

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram and Panel Schedules for size, rating, and configuration.

1.3 REFERENCES

A. NEMA AB 1 - Molded Case Circuit Breakers

B. NEMA PB 1 - Panelboards

C. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

D. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment

E. UL 67 - Panelboards

1.4 SUBMITTALS

A. Submit shop drawings for equipment and component devices under provisions of Section 16010.

B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Selective coordination study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to Fermilab.

PART 2 - PRODUCTS

2.1 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker

or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. See Section 16195 for additional requirements.

2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The panelboards for this project shall be fully rated unless otherwise specifically noted in the Drawings or Specifications.

2.2 MAIN AND DISTRIBUTION PANELBOARDS

A. General

1. Approved Manufacturers:

a. As shown on drawings.

B. Panelboards: NEMA PB 1; type as shown on the drawings.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with hinged door in door with flush lock. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All spaces shown on the one-line diagram shall be fully prepared spaces for future breakers.

G. Minimum Integrated Short Circuit Rating: 100,000 amperes rms symmetrical for 240 volt panelboards; 50,000 amperes rms symmetrical for 480 volt panelboards, or as shown on the drawings.

H. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

I. Solid State Molded Case Circuit Breakers: Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover.

J. Suitable for use as service entrance equipment.

2.3 BRANCH CIRCUIT PANELBOARDS

A. General

1. Approved Manufacturers:

a. As shown on drawings.

B. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1; circuit breaker type.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with door-in-door construction, concealed hinge, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future breakers.

G. All multiple-section panelboards shall have the same dimensional back box and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Provide handle lock-on devices for all breakers serving exit sign and lighting circuits with emergency battery units. Provide handle lock-on devices and red handles for breakers serving fire alarm panels.

J. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled on the drawings. Do not use tandem circuit breakers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards plumb as indicated on the drawings in conformance with NEMA PB 1.1.

B. Height: 6 feet to handle of highest device.

C. Provide filler plates for unused spaces in panelboards.

D. Provide typed circuit directory for each branch circuit panelboard. Label each circuit with the type of load and the name and number of the area served. Revise directory to reflect circuit changes required to balance phase loads.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION 16470

SECTION 16477 - FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses
B. Spare Fuse Cabinet

1.2 REFERENCES

A. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Types

B. UL 198E - Class R Fuses

C. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

D. NEMA FU 1 - Low Voltage Cartridge Fuses

E. NFPA 70 – National Electrical Code

1.3 SUBMITTALS

A. Submit product data under provisions of Section 16010.

1.4 EXTRA MATERIALS

A. Provide two fuse pullers for each class of fuse provided.

B. Provide three of each size and type of fuse installed.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – FUSES

A. Cooper Bussman
B. Eagle Electric Mfg. Co.; Cooper Industries
C. Mersen
D. Tracor; Littelfuse Subsidiary

2.2 FUSES

A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.

B. Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.

C. Fuses with ratings larger than 600 amperes: Class L (time delay), unless otherwise noted on the drawings.

D. Fuses with ratings larger than 200 amperes but equal to or less than 600 amperes: Class RK-1 (time delay), unless otherwise noted on the drawings.

E. Fuses with ratings less than or equal to 200 amperes (not including control transformer fuses): Class RK-5, unless otherwise noted on the drawings.

F. Control transformer fuses: Class CC (time delay).

G. Fuses for packaged equipment: Size and type as recommended by equipment manufacturer.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses where indicated on the drawings and specifications.

B. Install fuses in accordance with manufacturer's instruction.

C. Install fuses in packaged equipment as required by equipment manufacturer.

D. Install fuse with label oriented such that manufacturer, type, and size are easily read.

E. Install spare fuse cabinet next to the main entrance equipment.

END OF SECTION 16477

SECTION 16480 - MOTOR CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual motor starters
B. Magnetic motor starters
C. Combination magnetic motor starters

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule and One-Line Diagram for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508. Standard for Industrial Control Equipment

B. FCC Rules and Regulations, Part 15, Subpart J- Radio Frequency Interference

C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service

D. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

E. FS W-P-115 - Power Distribution Panel

F. FS W-S-865 - Switch, Box, (Enclosed), Surface-Mounted

G. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

H. NEMA AB 1 - Molded Case Circuit Breakers

I. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA KS 1 - Enclosed Switches

L. NEMA PB 1 - Panelboards

M. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; wiring diagrams that differentiate between manufacturer-installed and field-installed wiring; nameplate legends; size and number of bus bars per phase and ground; electrical characteristics including voltage, frame size and trip

ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and over-current protective devices.

D. Submit manufacturer's instructions under provisions of Section 16010.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to Fermilab.

B. Fuses and fuse pullers as specified on 16477.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 16010.

B. Deliver in 60 inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 16010.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic, and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 16010.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay, and toggle operator.

B. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, and toggle operator.

C. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, and toggle operator.

D. Enclosure: NEMA ICS 6; Type 1 or as shown on drawings.

2.2 MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

B. Full Voltage Starting: Non-reversing type, unless otherwise indicated.

C. Coil Operating Voltage: 120 volts, 60 Hertz, obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating, and control devices, plus 100% spare capacity.

D. Size: NEMA ICS 2; size as shown on the drawings.

E. Overload Relay:

1. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

F. Enclosure: NEMA ICS 6; Type 1.

G. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

H. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

I. Pushbuttons: NEMA ICS 2; START/STOP in front cover.

J. Indicating Lights: NEMA ICS 2; RUN: red in front cover.

K. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Relays: NEMA ICS 2.

M. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:

Size 1 - 100 VA
Size 2 - 100 VA
Size 3 - 150 VA
Size 4 - 300 VA
Size 5 - 300 VA
Size 6 - 300 VA

N. Provide phase loss protection relay with contacts to de-energize the starter for each starter serving motors 5 HP or greater.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions on concrete bases.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

END OF SECTION 16480

SECTION 16481 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives

1.2 RELATED SECTIONS AND WORK

A. Refer to the Variable Frequency Drive Schedule for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508

B. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

C. IEEE Standard 519-1992 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

D. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

D. Manufacturer's Installation 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 EXTRA MATERIAL

A. Furnish under provisions of Section 16010.

B. Provide two of each air filter.

C. Provide spare fuses as required in Section 16477.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 16010.

B. Accept controllers on site in original packing. Inspect for damage.

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. Lift only with lugs provided for the purpose. Handle carefully to avoid damage.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 16010.

B. Maintenance Data: 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 starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

D. Shop Drawings: For each VFD.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Nameplate legends.

c. Short-circuit current rating of integrated unit.

d. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS: Refer to Variable Frequency Drive Schedule.

2.2 DESCRIPTION

A. Converts 60 Hertz input power at voltage specified to a variable AC frequency and voltage for controlling the speed of AC squirrel cage motors. The controller shall be suitable for use with standard NEMA B squirrel cage 1.15 service factor induction motors without requiring any modifications to the motor or the drive.

B. Controller shall have sufficient capacity to provide speed control of the motors shown or noted throughout the specified environmental operating conditions.

C. Controller shall have the functional components listed below:

1. Door interlocked input circuit breaker/fused switch.
2. Input rectifier section to supply fixed DC bus voltage.
3. Smoothing reactor for DC bus.
4. DC bus capacitors.
5. Control transformer.
6. Separate terminal blocks for power and control wiring.
7. Terminal block for operator controls.
8. Sine weighted PWM generating inverter section.

2.3 RATINGS

A. Rated Input Voltage: Refer to Variable Frequency Drive Schedule 208V 480V.

B. Motor Nameplate (Drive Output) Voltage: Refer to Variable Frequency Drive Schedule. Refer to Mechanical Schedules.

C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

D. Operating Ambient: 0°C to 40°C.

E. Minimum Relative Humidity Range: 5% to 90% (non-condensing).

F. Minimum Elevation without Derating: 3300 feet.

G. Minimum Efficiency at Full Load: 96 percent.

H. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

I. Starting Torque: 100 percent of rated torque or as indicated.

J. Speed Regulation: Plus or minus 1 percent with no motor derating.

2.4 DESIGN

A. Pulse Width Modulated (PWM) Variable Frequency Drives:

1. Converter shall be of a diode bridge design with a sine-weighted PWM inverter section.

2. Main semi-conductors in the inverter section of controller shall be IGBT transistors capable of a carrier switching frequency of up to 8 kHz. If derating of the inverter is necessary to run at 8kHz, then the unit's derated currents must equal or exceed the motor full load currents listed in NEC Table 430-150.

3. All controllers supplied with semi-conductors capable of switching at less than 8,000 Hertz shall be supplied with a motor acoustic noise reduction filter.

4. Pulse width modulated (PWM) drives shall be supplied with drive input line reactors with a minimum impedance of 3%. Reactors shall be installed to filter entire drive input circuit.

5. Pulse width modulated (PWM) drives shall be supplied with drive input harmonic filter to reduce the total harmonic distortion to less than the IEEE519-1992 limits at the utility service entrance.

6. Drives that are located beyond the manufacturer's recommended maximum distance from the motor shall be provided with dV/dt (long lead) filters.

B. All drives shall have built-in diagnostic capability with status and fault indicators mounted on enclosure door. Complete operating instructions for diagnostics shall be mounted inside of the enclosure door.

C. Drive shall restart after power loss and under-voltage fault. The minimum number of restart attempts required shall be three, field adjustable.

D. The drive shall allow unlimited switching of the output without damage to the drive or motor.

2.5 PRODUCT FEATURES

A. Display: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, overtemperature, phase loss, input power ON, output voltage, output frequency, and output current.

B. Protection:

1. Input transient protection by means of surge suppressors.

2. Snubber networks to protect against malfunctions due to system transients,

3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

4. Motor thermal overload relay(s) adjustable and capable of NEMA Class 10 20 30 motor protection and sized per motor nameplate data. When multiple motors are connected to the VFD output, each motor shall have a manual starter with properly sized overload protection.

5. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

6. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.

7. Loss-of-phase protection.

8. Reverse-phase protection.

9. Short-circuit protection (fuses or circuit breaker).

10. Motor overtemperature fault.

C. Acceleration Rate Adjustment: 0.5 - 30 seconds.

D. Deceleration Rate Adjustment: 1 - 30 seconds.

E. Minimum Adjustment Range for the Lower Output Frequency shall be: 0 to 40 Hertz.

F. Minimum Adjustment Range for the Upper Output Frequency Range shall be: 40 to 90 Hertz.

G. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.

H. Provide unit mounted and remote user interface mounted minimum 10 feet from the drive. The drive user interface shall include:

1. MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.

2. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.
g. Operating speed in Hertz (default) and percent of full speed.

3. Drive user interface shall furnish access to all drive parameters required to configure drive for operation.

I. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.

J. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.

K. Provide adjustable skip frequencies on the drive output (minimum of three ranges).

L. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption, and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

M. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Fault or alarming status (code).
5. PID feedback signal (percent).
6. DC-link voltage (VDC).
7. Set-point frequency (Hz).
8. Motor output voltage (V).

Q. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

a. 0 to 10-V dc.
b. 0-20 or 4-20 mA.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.
e. RS485.
f. Keypad display for local hand operation.

3. Output Signal Interface:

a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1A) for remote indication of the following:

   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

R. Communications: Provide a communications card to interface VFD with Facility Management Control System (FMCS). Coordinate interface requirements with the FMCS provided under Section 15952. Interface shall allow all parameter settings of VFD to be programmed via FMCS control and displayed on FMCS operator workstation. Interface shall allow monitoring of all drive status parameters. Provide capability for VFD to retain these settings within the nonvolatile memory.

S. Where indicated on the plans, provide a three-contactor manual bypass:

1. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch or third contactor to allow maintenance of inverter during bypass operation.

2. All bypass circuitry shall be isolated from the variable frequency drive, either by barrier and separate doors within same enclosure, or by use of adjacent enclosure.

3. Bypass circuitry shall include pad-lockable energy isolating devices so lockout - tag-out can be performed to permit the VFD to be serviced or replaced while the motor operates in bypass mode.

4. All fire alarm and/or smoke control interconnections (e.g., air handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.

5. Provide a Drive-Bypass Selector Switch.

6. Provide nameplate with instructions for switching from drive to bypass and from bypass to drive. Provide instructions for isolating VFD for maintenance.

T. Control:

1. With the "drive user interface" in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the drive user interface manual analog speed control.

2. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.

3. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.

4. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD and motor shall not operate.

5. If applicable, signal from the fire alarm control panel shall shut down motor with VFD and bypass operation.

6. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

2.6 ACCESSORIES

A. Required for All Drives:

1. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

2. All VFD supplied for fans shall have dynamic or DC injection braking capability to provide a means of rapid deceleration of the AC motor in not more than one (1) minute. Adjust controls to stop the motor within 30 seconds.

3. All high intertia loads that cannot be stopped in 30 seconds with the VFD dynamic braking or DC injection braking shall be provided with a chopper module and dynamic braking resistor to stop the motor within 30 seconds.

B. As Shown on the Drawings:

1. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

2. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

3. Control Relays: Auxiliary and adjustable time-delay relays.

4. Standard Displays:

a. Output frequency (Hz).
b. Set-point frequency (Hz).
c. Motor current (amperes).
d. DC-link voltage (VDC).
e. Motor torque (percent).
f. Motor speed (rpm).
g. Motor output voltage (V).

5. Historical Logging Information and Displays:

a. Real-time clock with current time and date.
b. Running log of total power versus time.
c. Total run time.
d. Fault log, maintaining last four faults with time and date stamp for each.

6. Fabrication:

a. Enclosure: NEMA 250, Type 1 or as shown on drawings.
b. Finish: Manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The VFD manufacturer shall provide certification that heat test has been completed.

B. The Electrical Subcontractor shall have a factory service engineer present for the start-up, field calibration, and check-out of each VFD installed. Factory service engineer shall be required to return to the site for recalibration or set-up should unit not function as specified during system commissioning. All costs shall be a part of This Contract. Provide tag with date and signature of factory service Engineer on inside cover of each drive.

3.2 INSTALLATION

A. Install variable frequency drive equipment in accordance with the manufacturer's instructions.

B. Provide engraved phenolic nameplates under the provisions of Section 16195.

C. Connections: All conduit connections to the VFD shall be by flexible conduit.

D. Input, output, and control wiring shall each be run in separate conduits.

E. All interlocking required by the drive manufacturer shall be the responsibility of the Electrical Subcontractor.

3.3 STARTUP AND COMMISSIONING

A. Verify all settings, parameters, and adjustments with other subcontractors prior to startup. Make all adjustments and setting to coordinate with controls and equipment.

B. Accelerate the motor to full speed and verify operation. Decelerate the motor to a stop and verify operation. Slowly operate the motor over the speed range and check for resonance.

C. Make all adjustments and settings to coordinate with controls and equipment prior to Substantial Completion. Verify that drive is set for auto restart after power loss and undervoltage fault.

D. Document settings in the Operations and Maintenance manual.

END OF SECTION 16481

SECTION 16495 - TRANSFER SWITCH

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Automatic transfer switch and bypass/isolation switch

1.2 RELATED SECTIONS AND WORK

A. Refer to the Transfer Switch Schedule for rating and configuration.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in automatic transfer equipment with three (3) years documented experience.

1.4 REFERENCES

A. NEMA ICS 1 - General Standards for Industrial Control and Systems

B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers, and Assemblies

C. NEMA ICS 2-447 - AC Automatic Transfer Switches

D. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

E. UL 1008 - Standard for Automatic Transfer Switches

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Submit product data for transfer switches showing overall dimensions, electrical connections, electrical ratings, and environmental requirements.

C. Submit manufacturer's installation instructions under provisions of Section 16010.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 16010.

B. Include instructions for operating equipment.

C. Include instructions for operating equipment under emergency conditions when engine generator is running.

D. Identify operating limits which may result in hazardous or unsafe conditions.

E. Document ratings of equipment and each major component.

F. Include routine preventive maintenance and lubrication schedule.

G. List special tools, maintenance materials, and replacement parts.

1.7 REGULATORY REQUIREMENTS

A. Conform to applicable code for emergency and standby electrical systems.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Russelectric, Inc.

2.2 AUTOMATIC TRANSFER AND BYPASS/ISOLATION SWITCH

A. Description: NEMA ICS 2; automatic transfer switch with manual bypass switch.

B. Configuration: Draw-out type electrically-operated, mechanically-held transfer switch with manually-operated CONNECTED, TEST, and DISCONNECTED draw-out positions, and with mechanically-operated, mechanically-held transfer switch connected to bypass automatic switch.

C. Bypass Switch Ratings: Match automatic transfer switch for electrical ratings.

2.3 SERVICE CONDITIONS

A. Service Conditions: NEMA ICS 1.

2.4 RATINGS

A. Refer to the one-line diagrams for the available interrupting capacity (AIC) of the transfer switch. The transfer switch shall be series rated with the equipment feeding the transfer switch. The series rating shall be the larger of the two AIC values when the AIC rating of the equipment feeding the normal and emergency sides of the transfer switch is not equal.

B. Series rating with upstream devices shall be allowed per UL-1008.

2.5 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

B. Time Delay to Start Alternate Source Engine Generator: 0 to 10 seconds, adjustable.

C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.

D. Time Delay Before Transfer to Alternate Power Source: 0 to 30 seconds, adjustable.

E. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.

F. Time Delay Before Transfer to Normal Power: 0 to 30 minutes, adjustable; bypass time delay in event of alternate source failure.

G. Time Delay Before Engine Shut Down: 0 to 30 minutes, adjustable, of unloaded operation.

H. Engine Exerciser: Start engine every seven (7) days. Run for 30 minutes before shutting down. Bypass exerciser control if normal source fails during exercising period.

2.6 ENCLOSURE

A. Enclosure: NEMA ICS 6; Type 1.

2.7 ACCESSORIES

A. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION.

B. Test Switch: Mount in cover of enclosure to simulate failure of normal source.

C. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.

D. Transfer Switch Auxiliary Contacts: 2 normally open; 2 normally closed indicating switch to normal source or emergency source.

E. Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 Hertz from rated nominal value, values shall be field adjustable.

F. Alternate Source Monitor: Monitor each line of alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent Hertz from rated nominal voltage, values shall be field adjustable.

G. In-Phase Monitor: Inhibit transfer until source and load are within 30 electrical degrees.

H. Switched Neutral: Overlapping or fully rated 4th pole contacts.

I. Provide 2 N.O. and 2 N.C. isolated contacts to indicate:

1. Normal source available.
2. Emergency source available.
3. Exercise mode in operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field measurements are as instructed by the manufacturer.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means acceptance of existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION 16495

SECTION 16510 - LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories
B. Exterior luminaires and accessories
C. Lamps
D. Ballasts

1.2 REFERENCES

A. ANSI C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products

B. ANSI C82.77-2002 – Standard for Harmonic Emission Limits and Related Power Quality Requirements for Lighting Equipment

C. IEEE C2 - National Electrical Safety Code

1.3 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Submit product data sheets for luminaires, lamps, ballasts, and drivers. Include complete product model number with all options as specified. Submittal shall be arranged with fixtures listed in ascending order, and with each luminaire's associated lamp, ballast, or driver information following luminaire's product data. Failure to organize submittal in this manner will result in the submittal being rejected.

C. Submit lens product data, dimensions and weights if not included in product data sheet submittal.

D. Include outline drawings, support points, weights, and accessory information for each luminaire type.

E. LED luminaire submittals shall include photometric report per IESNA LM-79-08 for the latest generation system being furnished, including independent testing laboratory name, report number, date, luminaire model number, input wattage, luminaire, and light source specifications. Manufacturer origin of LED chipset and driver shall be submitted.

F. For all LED luminaires specified as dimmer controlled, submit dimmer device data that is approved by manufacturer of submitted luminaire and that Subcontractor proposes to furnish and install. Subcontractor is responsible for verifying that installed dimming controls are compatible with and approved by the luminaire manufacturer.

G. A point-by-point photometric calculations with statistical data shall be provided with the submittal for any luminaire submitted other than the basis of design as defined in 16010-1.14. A separate photometric calculation shall be submitted for

every space in which a substituted luminaire is to be installed. Each photometric calculation shall include a point-by-point diagram and average, low, high, average-to-low, and high-to-low statics for both luminaire and luminance.

1.4 EXTRA STOCK

A. Provide extra stock under provisions of Section 16010.

B. LED Light Engines or Modules: Five (5) percent of quantity installed, minimum of one (1) of each size and type.

C. Ballasts and LED Drivers: Five (5) percent of quantity installed, minimum of one (1) of each size and type.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Section 16010.

B. Protect luminaire finishes, lenses, and trims from damage during storage and installation. Do not remove protective films until construction cleanup within each area is complete.

1.6 WARRANTY

A. Light emitting diode (LED) light engines and drivers shall have a five-year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Self-Powered Exit Signs: Stencil face, 6 inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings. One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger. Provide with self-testing.

B. Self-Powered Emergency Lighting Units: One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger. Provide with self-testing.

C. Painted reflector surfaces shall have a minimum reflectance of 90%.

2.2 EXTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Listed for wet or damp location as scheduled. Fountain and pool luminaires shall be listed for submersible location to meet depth specified.

B. Provide low temperature ballasts or LED drivers, with reliable starting to -20°F.

2.3 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Light emitting diodes used in interior applications shall have a minimum color rendering index (CRI) of 80. Light emitting diodes used in exterior applications shall have a minimum color rendering index (CRI) of 70. Color temperature of the luminaires shall be as noted on the luminaire schedule.

B. LED chip arrays specified as color changing shall have chip colors as noted on the luminaire schedule.

C. LED chips shall be wired so that failure of one chip does not prohibit operation of the remainder of the chip array.

D. LED Driver:

1. Solid state driver with integral heat sink. Driver shall have overheat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 20%. Surge suppression device for all exterior luminaires.

2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type.

3. Driver shall have a minimum of 50,000 hours rated life.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Securely fasten luminaires to the ceiling framing member by mechanical means such as bolts, screws, rivets or listed clips identified for use with the type of ceiling framing members.

B. Support surface-mounted luminaires directly from building structure. Install luminaires larger than eight square feet (8 ft^2) or weighing more than 30 pounds independent of ceiling framing.

C. Support suspended or pendant mounted luminaires independent of ceiling grid with a minimum of two #12 gauge wires. Suspension assembly and anchors shall be capable of supporting 300 pounds dead load at each suspension point.

D. Adjust aimable luminaires to obtain lighting levels on objects and areas as directed to obtain desired lighting levels.

3.2 RELAMPING

A. Replace failed lamps at completion of work. If more than five percent of lamps of any type have failed, replace all lamps of type.

3.3 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.

3.4 LUMINAIRE SCHEDULE

A. As shown on the drawings.

END OF SECTION 16510

SECTION 16570 - LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Lighting control panels, control station and programming software.
B. Communications wiring and interfaces related to lighting controls.

1.2 QUALITY ASSURANCE

A. Manufacturers shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. All components and assemblies are to be factory pre-tested prior to delivery and installation.

C. Comply with NEC as applicable to electrical wiring work.

D. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

E. Panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Panels and accessories used for control of life safety and critical branch circuits shall be listed under UL 924 Emergency Lighting and Power Equipment.

F. All assemblies are to be in compliance with FCC emissions standards specified in Part 15 Subpart J for Class A applications.

1.3 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code
B. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference
C. UL Standard 916 Energy Management Equipment

1.4 SUBMITTALS

A. Submit product data under provisions of Section 16010.

B. Submit product data showing dimensions and ratings for relays, power supplies, control stations, and accessory modules.

C. Submit control riser diagram of the specific project system configuration.

D. Submit typical wiring diagrams for all components including, but not limited to, relay panels, relays, low voltage switches, control stations, and communication interfaces.

1.5 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 16010.

B. Accurately record location of control panels, stations, switches, power supplies, and control enclosures. Include description of switching and circuiting arrangements.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit emergency, operation, and maintenance data under provisions of Section 16010. Data shall also include the following:

1. Schedule for routine maintenance, inspection, and calibration of all lighting control devices and system components.

2. Complete narrative describing intended operation and sequence for each control scenario and system component, updated to reflect all changes resulting from commissioning of systems. Narrative shall indicate recommended settings for devices where applicable.

3. Replacement part numbers for all system components.

B. Identify installed location and labeling for each luminaire controlled by automated lighting controls.

C. Submit software operating and maintenance manuals, program software backup on compact disc or compatible media with data files, device address list, and a printout of software application and graphic screens, where applicable.

1.7 TESTING

A. System shall be functionally tested by a factory-authorized engineer. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system.

1.8 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two (2) years from date of commissioning.

B. Occupancy, vacancy, daylight sensors and controls shall have a five (5) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers:

1. Lighting Controls GR 2400

2.2 CENTRAL LIGHTING CONTROL FEATURES AND FUNCTIONS

A. Lighting control system shall be designed to allow control of lighting and associated systems via switches, preset/fader, LCD, A/V interface, BAS interface, and astronomical/time-of-day scheduling controls.

B. Clock events shall be activated by calendar schedule, by day type and/or specific day programming, including everyday, weekday, weekend, S, M, T, W, H, F, S, Holiday. Clock events shall also be activated by astronomical events, which will compensate for daylight savings time and will have programmable setback periods relative to sunrise and sunset.

C. The system shall be capable of implementing On commands, Off commands, commands for any relay, group or zone by means of digital wall switches, specification grade line voltage type wall switches, photocell, web-based software or other devices connected to programmable inputs in a lighting control panel.

D. Channels for grouping relays shall be provided, each with an associated pushbutton to toggle the channel ON/OFF and a terminal block for a separate dry contact input. Any number of relays in the panel can be assigned to each channel, with overlapping allowed. Channels shall be set up via communication line communications and networking. Each channel pushbutton shall provide LED status indication. The panel shall also have the ability to assign functions to relays independently of the channels. Panels shall be addressable with DIP switches or other local means to set panel address.

E. System shall accept any type of switch input, including momentary or maintained.

F. System shall support by relay or zone the "blink warning" function. System shall be capable of flashing lights Off/On prior to the lights being turned Off. The warning interval time between the flash and the final lights off signal shall be definable for each zone. Occupant shall be able to override any scheduled Off sweep using local wall switches within the occupied space. Occupant override time shall be locally and remotely programmable and shall not exceed two (2) hours.

G. System shall provide temporary override conditions for each relay or dimmer so that lights can always be turned on.

H. All programming and scheduling shall be able to be done locally at the master lighting control panel and remotely via the Internet. Remote connection to the lighting control system shall provide real-time control and real-time feedback. Lighting control system shall be able to be monitored by and take commands

from a remote PC. At any time, should the remote PC go offline, all system programming uploaded to the lighting control system shall continue to operate as intended.

I. All programs, schedules, time of day, etc, shall be held in non-volatile memory for a minimum of two (2) years at power failure. At restoration of power, lighting control system shall implement programs required by current time and date.

J. Lighting control shall be configured to allow individual users to turn lighting on and off with their PCs. Software shall be written for Windows operating system, with web page as the display and ActiveX controls that can be accessed through an Internet browser. Include at least three levels of password protection.

2.3 COMPONENTS

A. Lighting Control Panels:

1. Cabinets and Enclosures: NEMA 1 enclosure sized to accept required relays and dimmers. Surface-mounted cover as required, with captive screws in a hinged, lockable configuration.

2. Interior: Interiors shall be provided with installed and tested relays or dimming and interface modules.

3. Power Supply: Transformer assembly including internal overcurrent protection with automatic reset and metal oxide varistor protection against power line spikes.

4. Panel shall be provided with expansion space as shown on the drawings for ease of installation of other system components (e.g., timeclock and/or photocell controller). Terminals shall be included in the interior to accept a communication line for the connection of communication line switches to the system, or to allow a communication line to be run between multiple panels for network communications.

5. Refer to schedules and wiring diagram for size, rating, and configuration.

B. Accessory Enclosure:

1. Provide an accessory enclosure with mounting area and connections for communication line and optional power supply as needed for remote mounting of interface modules. Interface modules, including clocks, BMS/BAS interface, low voltage controls, etc., shall have their communication line cables connected to a terminal board in the accessory enclosure.

2. Additional power may be supplied, if needed, by installing a transformer power supply in the space provided in the enclosure.

C. Ethernet Connection Port - Interoperability:

1. System shall include an Ethernet port for connection to Fermilab's TCP/IP network, permitting remote management of system from local or wide area network connection.

2. Subcontractor shall coordinate with technology vendor to provide an Ethernet connection to (LCP) panel as specified by manufacturer.

D. Relays: Momentary-pulsed mechanically latching contactors with plug-in connector. Relays shall have mechanically latching contacts with single moving part design for improved reliability. Relays shall have the following characteristics:

1. Coil:

a. Magnetically held, momentary coil activation (50 milliseconds).
b. 2.2 VA max per relay to allow up to 20 relays to be controlled in parallel using class 2 wiring.
c. Split coil - 1/2 for ON, 1/2 for OFF.

2. Power Contacts:

a. 20 amp tungsten and NEMA electronic ballast rated.
b. Rated for 50,000 ON/OFF cycles at full load.
c. Support #10 - #14 AWG solid or stranded wire.
d. 120 and 277 volt rated.
e. 30 VAC Isolated contacts for status feedback and pilot light indication.
f. FCC approved for commercial and residential use.

2.4 CONTROL INTERFACES

A. Manual Switches, Stations and Plates:

1. Switches: Modular, momentary pushbutton, with addressable capabilities.

2. Switch shall digitally communicate with the lighting control system to control the luminaires assigned to that switch. The switch shall be able to actuate the functions based on the described sequence of operation and intended functions.

3. Preset/fader stations shall operate using programmable buttons and/or faders as indicated on drawings.

4. Integral Pilot Light or LED: Indicate that controls are active or powered by being on continuously when powered or when pushbuttons are actuated.

5. Labeling of buttons and faders shall be engraved/screened by manufacturer, using approved text returned with shop drawing submittals.

6. Manufacturer shall supply backboxes for all surface-mounted stations and flush-mounted half-gang stations.

7. Station control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via direct or network connection. Function options include: preset selection, manual mode, record mode, station lockout, raise/lower, macro, cue, and room join/separate.

B. Wall Plates: Match those scheduled in the General Electrical Equipment Schedule for materials, finish, and color. Use multi-gang plates if more than one switch is indicated at a location.

2.5 CENTRAL LIGHTING CONTROL SOFTWARE

A. Central lighting control software shall be licensed to Fermilab. License shall include updated from the lighting control manufacturer as needed to correct software errors and vulnerabilities and obsolescence of programming device operating system for a period of not less than 20 years at no additional cost to the Owner.

B. Lighting control software shall be an application software package that facilitates offline control system configuration. Software shall enable a computer to be connected online with lighting control panels for real-time preset selection, editing and recording.

C. Software shall provide graphic user interface of a visual representation of a specific area or zone indicating status of load(s). Software shall include astronomical timeclock, scheduling, holiday override and override functions. Software shall support the programming of station and component electronic security. Software shall include zone and device naming.

D. Graphic pages shall be designed to the Fermilab's selection from manufacturer's sample templates.

E. Access for remote monitoring, system support and diagnostics shall be provided via Ethernet port and web access.

F. System Control Software: Windows-based control software shall permit users to interface with control panel components via Ethernet connection.

1. Software shall permit configuration of control stations, zones, and device parameters. Each device shall have an independent address on the system network, allowing individual programming of each device from the workstation.

2. Software shall allow user to manage astronomical and scheduled events via an intuitive calendar interface. Multiple overlapping calendar events can be active at any time, with varying start, stop, fade and sequencing parameters.

3. Software shall serve as a programming interface only. Once user completes updating, all scheduling and other data is stored at each panel for execution. This provides redundancy for lighting controls in the event of failure of any given network component.

2.6 CONDUCTORS AND CABLES

A. Control Wiring:

1. Where installed with the line-voltage wiring, control wiring shall be copper conductors not smaller than No. 16 AWG with insulation voltage rating and temperature rating equal to that of the line-voltage wiring, complying with Division 16 Section 16120 "Wire and Cable."

2. Tap conductors to switches or relays: Stranded copper conductors of 16 AWG or solid 16 or 18 AWG with insulation rating equal to that of the line-voltage wiring.

3. Tap conductors to dimming ballasts: Solid copper conductors of 18 AWG with insulation voltage rating equal to that of the line-voltage wiring and insulation temperature rating not less than 90°C.

4. Network cabling as required by manufacturer.

B. Splices and Taps:

1. Tapping or wire trap connectors shall be used to splice all Class 1 and Class 2 control wiring. Twist-on, wire-nut type connectors are not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.

B. All wiring shall be installed in conduit.

C. All branch load circuits shall be live tested before connecting the loads to the lighting control panel.

3.3 SUPPORT SERVICES

A. System Startup:

1. Manufacturer shall provide factory authorized technician to confirm proper installation and operation of all system components.

B. Testing:

1. System shall be completely functional tested by a factory-authorized technician. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system components.

2. Programming of initial zones, schedules, lighting levels, control station groups, and sensor settings shall be performed by a factory-authorized technician. Lighting Control Matrices shown on drawings shall serve as a basis for programming, However, all final decisions regarding groups and schedules shall be at the direction of Fermilab. The following procedures shall be performed at a minimum:

a. Confirm that schedules and time controls are configured to meet specified performance criteria and Fermilab's operating requirements.

C. Training:

1. Manufacturer shall provide competent factory-authorized technician to train Fermilab personnel in the operation, maintenance and programming of the lighting control system. Submit training plan with notification seven (7) days prior to proposed training dates.

2. Training duration shall be no less than four (4) hours.

D. Documentation:

1. Manufacturer shall provide system documentation including:

a. System one-line showing all panels, number and type of control stations and sensors, communication line, and network.

b. Drawings for each panel showing hardware configuration and numbering.

c. Panel wiring schedules.

d. Typical diagrams for each component.

END OF SECTION 16570

SECTION 16611 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Static uninterruptible power supply

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for ratings configuration.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in UPS equipment and battery systems with three (3) years documented experience.

B. Operate system for 24 hours at full load before shipping.

1.4 REFERENCES

A. ANSI/IEEE 446 - Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

B. ANSI/IEEE 493 - Recommended Practice for Design of Reliable Industrial and Commercial Power Systems

C. ANSI/IEEE 519 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

D. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Provide battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and airflow requirements.

C. Submit product data for major components, such as batteries. Include catalog sheets and technical data sheets to indicate physical data and electrical performance.

D. Submit manufacturer's installation instructions under provisions of Section 16010.

E. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

1.6 SPARE PARTS

A. Provide spare parts under provisions of Section 16010.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 16010.

B. Store and protect products under provisions of Section 16010.

C. Protect equipment from extreme temperature and humidity by storing in a conditioned space.

D. Protect equipment from dust and debris by wrapping unit in dust-tight cover and storing away from construction activity.

1.8 SYSTEM DESCRIPTION

A. System Configuration: Continuous duty on-line rectifier and inverter.

B. Redundant system with separate static switch and external bypass line.

C. Components: System includes batteries and battery disconnect switch; regulated solid state rectifier/charger; static transistorized pulse width modulated SCR type 6 step inverter; SCR type static transfer switch with isolation and wraparound breakers; maintenance bypass switch; filters, and breakers; monitors, sensors, and control equipment and circuits.

D. Design Standards: In accordance with ANSI/IEEE 446, ANSI/IEEE 493, ANSI/IEEE 519, and U.L. 1778.

E. Utility Power Available: Rectifier/charger supplies load through inverter and maintains battery in fully-charged "float" condition.

F. Utility Power Failure: Load supplied from battery through static inverter if utility power drops below preset limits, or fails. There is no output disturbance transmitted to load.

G. Utility Power Returns: Rectifier/charger supplies power to load through inverter while it recharges battery. There is no output disturbance transmitted to load.

H. Rectifier/Charger or Battery Failure: Static switch transfers load to synchronized utility power, without disturbance, when inverter output deviates beyond specified quality limits. When inverter output returns to acceptable operation, it is synchronized to utility power, and after preset timing interval, static switch returns load to inverter without disturbance.

I. Overload or Short Circuit: Static switch transfers load to utility power during load inrush and clearing of faulted branch circuits; load automatically transfers back to inverter without disturbance.

J. Inverter Failure: Static switch transfers to utility power without disturbance, and remains until manually returned.

K. Maintenance Operation: Manual load transfer to utility power using bypass switch. During bypass mode, operation of system or static switch does not affect power to load.

1.9 PROJECT RECORD DOCUMENTS

A. Provide installation, and maintenance manuals under provisions of Section 16010.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 16010.

B. Include description of operation and servicing procedures; list of major components; recommended remedial and preventive maintenance procedures; spare parts list.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Do not store or install unless temperature is maintained between 32°F and 104°F, at a relative humidity less than 95% (non-condensing).

1.12 WARRANTY

A. Battery: Provide 20 year warranty under provisions of Section 16010, pro-rated after first year on straight line basis.

B. Warranty: Include coverage of travel, labor, parts, and service.

1.13 MAINTENANCE SERVICE

A. Furnish service and maintenance of uninterruptible power supply for one (1) year from Date of Substantial Completion.

B. Include coverage of travel, labor, parts, and service.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - STATIC UNINTERRUPTIBLE POWER SUPPLY

A. Refer to Drawings.

2.2 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

A. System Continuous Rating: As shown on the drawings, over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at any load from full load to no-load.

B. Battery Capacity: Capable of operating at full load for 10 minutes.

C. Voltage Rating: 208Y/120 volts, 3 phase input; 208Y/120 volts, 3 phase output.

D. Input Voltage Limits: +10 percent/-15 percent.

E. Input Frequency: 60 ±3 Hertz.

F. Input Current Limit: Adjustable to maximum of 125 percent of that required to operate at full load with battery bank on float charge.

G. Current Walk-In: 25 to 100 percent in 15 seconds.

H. UPS Power Factor Over Full Range of Loads and Input Voltages: 74 to 100 percent, lagging.

I. Harmonic Distortion of Input Current Wave Form: 5 percent maximum at full load.

J. Output Voltage Regulation:

1. ±0.5 percent for balanced load, full range of DC input and no load to full load variations.

2. ±2 percent for 50 percent unbalanced load, full range of DC input and no load to full load variations.

3. ±5 percent during maximum overload of the system.

K. Output Voltage Adjustment: ±5 percent.

L. Output Free Running Frequency: 60 Hertz ±0.1 percent.

M. Frequency Adjustment: ±2 Hertz.

N. Output Harmonic Distortion: Maximum 5 percent rms total harmonic distortion (THD) and maximum 3 percent any single harmonic, at rated frequency and voltage, from 10 percent load to full load and over battery voltage range, measured into a linear load.

O. Voltage Transient Response for Application of 0 to 50 Percent, 50 to 100 Percent, 100 to 50 Percent, and 50 to 0 Percent Step Loads, and Transfer To and From Bypass Line:

1. +8, -10 percent for a maximum of 8.3 milliseconds.

2. ±5 percent for a maximum of 25 milliseconds.

3. ±3 percent for a maximum of 50 milliseconds.

4. Recovery to steady state within 100 milliseconds after any out-of-tolerance variation.

P. Phase Displacement:

1. 120 ±1 degree for balanced loads.

2. 120 ±4 degrees for 50 percent unbalanced loads.

Q. Three-phase Overload Ratings:

1. 1000 percent for 5 cycles; via static switch.

2. 150 percent for 10 seconds.

3. 125 percent for 10 minutes.

R. Output Current Limit: 150 percent of rated output current.

S. Voltage Unbalance: 3 percent maximum line-line with 100 percent load unbalance.

T. Efficiency: 91 percent at full load. Measure efficiency of unit including battery and isolation transformer losses.

U. Surge Protection: IEEE 587, Class A & B.

2.3 PHYSICAL CHARACTERISTICS

A. All materials of the UPS shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service, except as required during factory testing. All active electronic devices shall be solid-state. All power semi-conductors shall be hermetically sealed. All relays and semi-conductors shall be dust-tight.

B. Wiring: Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA, and applicable local codes and standards. All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked.

C. All power, control, and printed circuit components shall be mounted in bolt-on and/or swing-out type assemblies for ease of maintenance and replacement. Replacement of components shall not require the use of a soldering iron.

D. Construction and Mounting: The UPS shall be NEMA Type 1 enclosures, designed for floor mounting. The UPS shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling. Wire runs shall be protected in a manner which separate power and control wiring. Provisions shall be protected in a manner which separate power and control wiring. Provisions shall be made in the cabinets to permit installation of input, output, and external control cabling, using raceway or conduit.

E. Ventilation: Adequate ventilation shall be provided to insure that all components are operated within environmental ratings. Cooling fans shall be redundant. All fans are to be equipped with fan failure sensors connected to an alarm on the UPS control panel.

F. Temperature sensors shall be provided to monitor UPS internal temperature. Upon detection of temperatures in excess of manufacturer's recommendations, the sensors shall cause audible and visual alarms to be sounded on the UPS control panel. A separate room ambient temperature sensor shall be provided to give an alarm if the temperature of the inlet air to the UPS is above specified limits.

2.4 RECTIFIER/CHARGER

A. The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert AC to regulated DC for input to the inverter and for charging the battery.

B. Battery Charge Current Limiting: The rectifier/charger shall be equipped with a battery charge current limit circuit that shall limit battery charging to an adjustable level of 2% to 25% of full rectifier input current. The circuit shall have a second adjustment to provide greater limiting when signaled by the emergency generator. This circuit shall allow input power limiting but shall not cause battery discharge when a low AC input voltage condition occurs. Battery charge current limit is to be set at 15% for normal operation and 2% for "generator" operation. Electrical Subcontractor shall make required connections to generator.

C. Input Current Walk-In: The rectifier/charger shall provide feature which upon AC power return to the AC input bus, after the UPS has been operating on battery power or has been de-energized, limits the total initial power requirement at the input terminals to 20% of rated load, and gradually increases power to 100% of full rating over the 15-second time interval.

D. Fuse Failure Protection: Semi-conductors in the rectifier/charger shall be fused with fast-acting fuses so that loss of any semi-conductor shall not cause cascading failures. All fuses shall have a blown fuse indicator with an alarm light on the control panel.

E. Output Filter: The rectifier/charger shall have an output filter to minimize ripple current into the battery. Under no conditions shall ripple current into the battery exceed 2% RMS. The filter shall be adequate to insure that the DC output of the rectifier/charger will meet the input requirements of the inverter. The inverter shall be able to operate from the rectifier with the battery disconnected.

F. Battery Recharge: In addition to supplying power for the load, the rectifier/charger shall be capable of recharging the battery as specified herein. The charging rate shall be sufficient to restore the battery from discharge to 95% charge within ten (10) times the discharge time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.

G. Battery Equalize Charge: An automatic equalize charge timer feature shall be provided to automatically apply an equalize voltage to the battery after a 5 second or longer utility outage. The duration of equalize charge time shall be adjustable from 0-72 hours. Manual override shall be provided for the automatic equalize circuit.

H. Over-voltage Protection: There shall be DC over-voltage protection so that if the DC voltage raises to the pre-set limit, the UPS is to shut down automatically and the load transferred to the bypass line uninterrupted.

2.5 INVERTER

A. The term inverter shall denote the equipment and controls to convert DC from the rectifier/charger or battery to precise AC to power the load. The inverter shall be solid-state, capable of accepting the rectifier/charger or battery output and providing rated output. The inverter is to be power SCR type.

B. Overload Capability: The inverter shall be able to sustain an overload across its output terminals up to 150% for 30 seconds without reducing output voltage. The inverter shall be capable of at least 300% current for short circuit conditions. If the short circuit is sustained, the inverter shall shut down and disconnect automatically from the critical load bus.

C. Output Frequency: Output frequency of the inverter shall track the static bypass source provided source frequency maintains 60 Hz ± 0.5 Hz to maintain synchronous operation for automatic transfers. If the bypass source fails to maintain proper frequency then control shall revert to an internal oscillator. The oscillator shall be temperature compensated and hold the inverter output frequency to ±0.1% for steady-state and transient conditions. Drift shall not exceed 0.1% during a 24 hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.

D. Phase Balance: Electronic controls must be used to provide individual phase voltage compensation to obtain phase balance under all conditions including up to 50% load unbalance.

E. Internal Protection: Fault sensing and static isolation shall be part of the inverter as well as an output circuit breaker for removal of a faulted module from the load, without affecting the critical load but beyond the stated limits.

F. Fuse Failure Protection: Semi-conductors in the inverter shall be fused with fast acting fuses to prevent cascading failures. Each fuse shall be provided with blown fuse indicator with an alarm light on the control panel.

G. Load Sharing: The inverter shall be capable of load sharing operation with like UPS modules without the use of master controls, oscillators, or sharing reactors. The inverters shall load share to within ± 5% of the average individual inverter load current.

2.6 SYSTEM PROTECTION

A. Built-in Protection: Against surges, sags, and over-current from the AC source, over-voltage and voltage surges from output terminals of paralleled sources, and load switching and circuit breaker operation in the distribution system.

B. The UPS shall be protected against sudden changes in output load and short circuits at the output terminals. The UPS shall have built-in protection against

permanent damage to itself and the connected load for all predictable types of malfunctions.

C. Fast-acting current limiting devices shall be used to protect against cascading failure of solid-state devices. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the reason for tripping. The load shall be automatically transferred to the bypass line uninterrupted for an internal UPS malfunction. Open protective devices shall be indicated by Light Emitting Diodes (LEDS) on the control panel.

2.7 DISPLAY AND CONTROLS

A. The term UPS Module Control Panel, as used herein, denotes that portion of the UPS module containing the display screen and control functions. The display panel shall be Liquid Crystal type to provide complete monitoring and control through the use of menu-prompted commands. Switches shall be used to select and execute operations from a Master Menu. The display and control panel shall be mounted on the control section door.

B. UPS module system logic and control programming shall be resident in Application Specific Integrated Circuits. Logic components shall be physically isolated from heat sources and voltage hazards. There shall be two power supplies for the logic and control circuits, one connected to the input AC source and the other connected to UPS module output.

C. Monitoring: UPS module monitoring shall be provided by a microprocessor-based graphic display capable of simultaneously reporting input and output and battery voltage and current; output frequency and total load KVA and KW for all three phases, within 1% accuracy.

1. History File: The control system shall maintain this information in discrete windows updating memory on a First-In First-Out basis. This shall provide status recall of a period of at least 256 milliseconds (64 windows); 160 milliseconds before the malfunction (40 windows), and 96 milliseconds after the malfunction (24 windows).

2. Power Flow Indication: Power flow indicators shall graphically depict whether the load is being supplied from UPS, bypass or battery and provide, on the same screen, input, output and battery voltage, amperages, frequency, KVA and KW. The following components must be indicated:

a. AC Input Circuit Breaker
b. Battery Circuit Breaker
c. Inverter Output Circuit Breaker
d. Bypass Switch
e. Static Transfer Switch (Off-Line/Available)

3. Battery Status Indicator: The battery status indicator shall display DC alarm and shutdown voltages and maintain the battery voltage drop

during discharge. Battery time remaining after a power outage shall be graphically displayed to permit prediction of battery shutdown.

D. Alarms: The control panel shall report the system level alarms listed below. An audible alarm is to be activated when any of the above alarms occur. All alarms shall be displayed in text form.

1. Input Power Fail
2. Output Overload
3. Overload Shutdown
4. Overload Transfer
5. Emergency Power Off
6. DC Over Voltage
7. DC Cap Fuse
8. Ambient Over-temp
9. UPS Over-temp
10. Over-temp Shutdown
11. Low Battery Reserve
12. Battery Disconnected
13. Battery Discharging
14. Rectifier Fuse Failure
15. Inverter Fuse Failure
16. Fan Failure
17. Static Switch Disabled
18. Bypass Not Available
19. Auto Transfer to Bypass
20. Reverse Power
21. Control Power Failure
22. Load on Bypass
23. Output Over/Under Voltage

E. Controls: System level control functions shall be:

1. UPS/Bypass Transfer Pushbuttons.
2. AC Output Voltage Adjust 5%.
3. Battery Circuit Breaker Trip Pushbutton.
4. Emergency Power Off Pushbutton with Protective Cover.
5. Alarm Silence Pushbutton.
6. Control Enable Pushbutton.
7. Display Control Switches.
8. Alarm Reset Switch.

F. Manual Procedures: Start-up, load transfers, and shutdown procedures shall be detailed on the display panel in text and graphic form.

1. Start-Up:

   a. Step-by-step procedure screen.
   b. Walk-in display screen to simultaneously indicated DC volts, output volts, and input phase amps.
   c. Mimic screen to indicate power flow.

2. Load Transfers:

   a. Step-by-step procedure screen.
   b. Mimic screen to indicate power flow.

3. Shutdown:

   a. Step-by-step procedure screen.
   b. Mimic screen to indicate power flow.

G. Emergency Power Off: The UPS control panel shall have a local emergency shutdown. Pressing the emergency shutdown shall cause:

1. Uninterrupted transfer of the load to bypass.
2. The input, output, and battery breakers.
3. Power off circuit, which completely removes power from the critical bus when activated.

H. Self-Diagnostics: The UPS module shall be provided with the following built-in diagnostics for troubleshooting and circuit alignment aids:

1. Rectifier in control mode.
2. UPS synchronizing with critical load bus.
3. Positive DC bus ground fault.
4. Negative DC bus ground fault.
5. Bypass frequency higher than system output frequency.
6. Bypass frequency lower than system output frequency.
7. Automatic static transfer lockout.
8. Command given to close inverter output circuit breaker.
9. Command given to close bypass switch.
10. Command given to open inverter output circuit breaker/bypass switch.
11. Degree of overload.
12. Under-voltage trip for battery disconnect switch.
13. Under-voltage trip for input circuit breaker.

I. Remote Monitoring Capability: UPS control circuits shall be interfaced with the site central monitoring system (CMS). Interface shall be built into the UPS. The site monitoring signal processing module shall be factory installed. The following shall be available for display:

1. Metering:

   a. Bypass volts (line-line, all phases)
   b. Critical bus volts (line-line & line-neutral, all phases)
   c. Critical bus current (all phases)
   d. Critical bus frequency
   e. Critical bus KVA
   f. Critical bus KW
   g. DC volts
   h. Battery amps (±)
   i. % Capacity

2. Digital Alarms:

   a. Fuse Cleared
   b. Output Overload
   c. Emergency Power Off
   d. Ambient Over-temp
   e. Battery Discharging
   f. Low Battery Reserve
   g. Load On Bypass
   h. Static Switch Disabled
   i. Battery Disconnected
   j. Module Cooling Failure (Fan Failure or Over-temp)
   k. Control Power Failure

3. Alarm Outputs: The following will have a N.O. isolated contact for remote indication on the RTU provided by others. Electrical Subcontractor shall route conduit and wire, make all connections.

   a. UPS System Mode
   b. Battery Discharging
   c. Low Battery Reserve
   d. UPS Alarm Condition

J. Communication Port: The UPS shall be provided with an RS-232 port capable of interfacing with a remote location. All monitoring information shall be capable of being downloaded to remote device.

2.8 STATIC TRANSFER SWITCH

A. The term static transfer switch shall denote the solid-state device that automatically transfers the critical load to bypass without interruption if the UPS cannot supply continuous power. The term bypass switch shall denote the electromechanical device that will connect the load to bypass. Automatic load transfers are to be initiated when a malfunction occurs within the UPS or a sustained system overload occurs.

B. Momentary Overloads: In the event of a branch load circuit fault or load current inrush, the static transfer switch is to pulse-on for at least 40 milliseconds allowing at least 1000% load current to flow from bypass line to clear the overload. If the overload is cleared, a load transfer shall not be made. If the overload is not cleared, then the transfer is to be accomplished maintaining load voltage within specified limits.

C. Automatic Closing: The static transfer switch is to be of the energy saving type. Once the load is transferred to the bypass line by the static transfer switch, the bypass switch is to automatically close removing the static transfer switch from the power flow.

D. Manual Transfers: A manual load transfer between the UPS and bypass line is to be initiated from the control panel. All transfers from bypass to the inverter shall be manually initiated.

E. Switch Isolation: The static switch SCR device shall include series connected switch/circuit breaker and backfeed circuit monitoring per U.L. Standard 1778 for automatic (and manually) initiated circuit isolation of static switch SCR device.

2.9 BATTERY DISCONNECT BREAKER

A. The UPS shall have a properly rated circuit breaker (500 VDC) to isolate it from the battery.

B. The switch shall be located in the battery compartment of the UPS module housing. When open, there shall be no battery voltage in the rectifier/inverter compartment.

C. The UPS shall automatically be disconnected from the battery by opening the switch when the battery reaches the minimum discharge voltage level or when signaled by other control functions.

D. The UPS shall be provided with a pushbutton to trip the breaker from the control panel.

2.10 BATTERY

A. Storage Battery: Valve regulated (sealed, reduced maintenance) type. Maximum specific gravity of 1.3, and minimum cell end voltage of 1.65 volts. Heavy duty industrial design. Provide with impact resistant plastic case which meets or exceeds 94V2 to meet U.L. Standard 1778 requirements.

B. Batteries shall be furnished with flame arrestors, lead covered solid copper terminal posts, and transparent container to allow visual inspection of the plates and sediment spaces.

C. Battery system shall be furnished as a part of the UPS system and sized to maintain the rated UPS system load output for the specified duration. Submit battery Amp-hour rating, cell end voltage, specific gravity, and battery system calculations with shop drawing submittals.

D. Battery system design life shall be 20 years under full float operation and shall be provided with a pro rata cycle duty warranty based on the following discharges at the fifteen minute rate:

	CYCLE DURATION			
NUMBER OF CYCLES	**0 to 30s**	**30s to 1M**	**1M to 5M**	**5M to 15M**
	3,700	1,125	410	225
	2,700	600	200	120
	10,500	2,100	660	300
	4,571	2,560	853	481

E. The battery system shall provide 100% of specified capacity at initial start-up.

F. Batteries shall be mounted in separate battery cabinet. Cabinet shall be a NEMA 1 floor standing enclosure structurally sized for batteries weight and size.

Housing shall be similar in construction and appearance to rectifier/inverter housing.

G. Rack system shall be painted with corrosion resistant paint, and supplied with all required lead plated copper bolted connectors, terminal lugs, cable supports, rack mounting bolts, and accessories. Provide acid resistant aisle matting adjacent to racks.

H. Racks shall be sized to fit into battery room as shown on the drawings and configured to hold batteries totaling 250 VDC maximum. Subcontractor shall size conductors and conduit between UPS and battery disconnect breaker, and between battery disconnect breaker and battery racks as required by UPS supplier. All cables leaving a continuous rack area shall be in conduit.

I. Provide the following battery system accessories:

1. Set of battery identification numbers.
2. Battery arrangement and wiring diagram indicating battery numbers.
3. Lifting strap and spreader block.
4. Anti-corrosion compound.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install UPS as shown on the drawings, and in accordance with manufacturer's instructions.

B. Racks and equipment shall be installed level and in line with walls and room.

C. The system provider shall provide a factory technician to supervise the system installation.

3.2 FIELD QUALITY CONTROL

A. Perform field inspection and testing under provisions of Section 16010.

B. Field Tests: Verify specification performance criteria; measure battery discharge and recharge times, measure and record battery float voltage and charging current, perform a battery capacity test, and measure and record all bolted battery connection resistances, and visually inspect all electrolyte levels and measure specific gravity of all cells; simulate fault in each system component and utility power; operate unit at 77°F for eight hours; at rated load using resistive bank; and other tests as recommended by manufacturer.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 16010.

B. Include services of technician to supervise adjustments, final connections, and system testing.

C. The system provider's factory technician shall start up the system and perform all require acceptance tests to demonstrated the system is functional.

3.4 TRAINING

A. The provider shall provide 4 hours of training as specified under section 16010.

END OF SECTION 16611

SECTION 16721 - FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire alarm and detection systems

B. One-way Emergency Communications System with voice notification within-building.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in smoke detection and fire alarm systems with ten years' experience.

B. Installer: A factory-authorized licensed electrical or security subcontractor with five years' experience in the design, installation and maintenance of fire alarm systems by that manufacturer.

C. Qualifications: The person managing/overseeing the preparation of shop drawings and the system installation/programming/testing shall be trained and certified by the system manufacturer and shall be Fire Alarm Certified by NICET, minimum Level 2. This person's name and certification number shall appear on the start-up and testing reports.

1.3 REFERENCES

A. NFPA 70 - National Electrical Code

B. NFPA 72 - National Fire Alarm and Signaling Code

C. NFPA 101 - Life Safety Code

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010 and as noted below.

1. Failure to comply with all of the following and all of the provisions in 16010 will result in the shop drawing submittal being rejected without review.

2. Failure to submit the fire alarm without all requirements fulfilled in a single comprehensive submittal will be grounds to require a complete resubmittal.

B. Provide product catalog data sheets as shop drawings.

1. Provide a product catalog data sheet for each item shown on the General Electrical Equipment Schedule and for each piece of equipment that is not shown on the drawings, but required for the operation of the system.

2. Where a particular General Electrical Equipment Schedule item has one or more variations (such as those denoted by subscripts, etc) a separate additional product catalog data sheet shall be provided for each variation that requires a different part number to be ordered. The corresponding General Electrical Equipment Schedule symbol shall be shown on the top of each sheet.

3. Where multiple items and options are shown on one data sheet, the part number and options of the item to be used shall be clearly denoted.

C. Submit CAD floor plans as shop drawings:

1. The complete layout of the entire system, device addresses, auxiliary equipment, and manufacturer's wiring requirements shall be shown.

2. A legend or key shall be provided to show which symbols shown on the submittal floor plans correspond with symbols shown on the Contract Documents.

D. With regard to all fire alarm circuits, provide the following: manufacturer's wiring requirements (manufacturer, type, size, etc.) and voltage drop calculations.

E. Provide installation and maintenance manuals under provisions of Section 16010.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

G. Provide information on the system batteries as follows: total battery capacity, total capacity used by all devices on this project, total available future capacity.

H. Voice Alarm Communication System: Submit equipment layout, grounding schematic, amplifier power calculations, and wiring diagram.

I. Submit photocopy proof of NICET certification of the person overseeing the preparation of drawings and installation/testing.

J. When required to comply with local or state regulatory reviews, the fire alarm submittal shall have a Professional Engineer's stamp and signature of the state in which the project is completed. NOTE: Fermilab cannot stamp and seal submittal drawings not prepared under their supervision.

1.5 EXTRA MATERIALS

A. Provide spare parts under provisions of Section 16010.

B. Provide three (3) keys of each type.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 16010.

B. Store and protect products under provisions of Section 16010.

1.7 REGULATORY REQUIREMENTS

A. System: UL or FM Global listed.

B. Conform to requirements of NFPA 101.

C. Conform to requirements of Americans with Disabilities Act (ADA).

D. Conform to UL 864 Fire Alarm, UL 1076 Security.

1.8 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying fire alarm specific design documents describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Subcontractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

B. This section of the specifications includes the furnishing, installation and connection of the microprocessor controlled, intelligent reporting, fire alarm equipment required to form a complete coordinated system that is ready for operation. It shall include, but is not limited to, alarm initiating devices, emergency communication systems, control panels, auxiliary control devices, annunciators, power supplies, and wiring as indicated on the drawings and specified herein.

C. Fire Alarm System: NFPA 72; Automatic and manual fire alarm system, non-coded, analog-addressable with automatic sensitivity control of certain detectors, multiplexed signal transmission.

D. Voice Communication: The facility shall have an emergency voice alarm communication system. The digitized recorded voice message shall notify occupants that a fire condition has been reported.

E. System Supervision: Provide electrically supervised system, with supervised Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC). Occurrence of single ground or open condition in initiating or signaling circuit places circuit in TROUBLE mode. Component or power supply failure places system in TROUBLE mode.

F. Alarm Reset: Key-accessible RESET function resets alarm system out of ALARM if alarm initiating circuits have cleared.

G. Drawings: Only device layouts and some equipment have been shown on the contract drawings. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted on the shop drawings.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 16010.

B. Include location of end-of-line devices.

C. Provide a CAD drawing of each area of the building (minimum scale of 1/16” = 1’-0”) showing each device on the project and its address. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

D. Submit test results of sound pressure level (dBA) and intelligibility (STI) with the rooms tested designated on the floor plan. Notification devices shall have the tap wattage designated.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 16010.

B. Include operating instructions, and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer’s representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

F. Include shop drawings as reviewed by Fermilab and the local Authority Having Jurisdiction.

1.11 WARRANTY

A. Provide one (1) year warranty on all materials and labor from Date of Substantial Completion.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Siemens Fire Safety

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. Control Panel: Modular, power-limited electronic design. Provide surface wall-mounted enclosure as shown on plans. Enclosure shall be minimum 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

B. Each Signaling Line Circuit (SLC loop) shall not be loaded over 80% of the maximum device capacity. For example, in the minimum system capacity column listed below, if the fire alarm manufacturer's system capacity of analog sensors per loop is 99 devices, then no more than 79 devices shall be wired on that loop. The minimum system capacity shall be as follows:

Minimum Total Addressable Points: 250

Minimum Total SLC loops (including board, ready for field connections): 2

C. Signal Line Circuit Board (SLC):

1. Each board shall communicate directly with each addressable analog sensor and binary input to determine normal, alarm, or trouble conditions. Analog signals would be used for automatic test and determination of maintenance requirements.

2. Each board shall contain its own microprocessor and shall be provided to monitor addressable inputs and to control addressable outputs (addressable relays). The board shall communicate and provide power to all devices on its loop over a single pair of wires, except where 4-wire devices require a separate power circuit.

3. Class B, Style 4: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

D. Notification Appliance Circuit (NAC) Board:

1. Each board shall contain its own microprocessor and shall be provided to control each notification appliance circuit. The board shall communicate and provide power to all devices on its loop.

2. Class B, Style Y: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

E. Central Processing Unit:

1. The central processing unit (CPU) shall communicate with the monitor and control all other modules in the panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the CPU.

2. The CPU shall execute all control-by-event programs for specific action to be taken if a designated situation is detected in the system. A real-time system clock for time annotations on the display and printer shall be included.

3. All power for the unit shall be supervised and supplied by the FAP.

F. Display:

1. The board shall provide all controls and indicators used by the system operator and may also be used to program all control panel parameters.

2. The board shall provide an alphanumeric array for display of custom alphanumeric labels for all addressable points. It shall also provide indicators for AC Power, System Alarm, System Trouble, Display Trouble and Signal Silence.

3. Displayed descriptions of addressable points shall include actual room names/numbers selected by Fermilab. This information shall be obtained prior to programming. Room names/numbers shown on floor plans shall not be used.

4. The board shall provide a touch key-pad with control capability to command all system functions and entry of any alphanumeric information. Twenty different passwords with four levels of security shall be supported to prevent unauthorized manual control or programming.

G. Memory: The CPU and display interface board shall be augmented by non-volatile field programmable memory. EPROM memory will also be allowed provided the memory is burned in with minimum expansion capability equal to the total system capacity of the panel. Memory shall not be lost upon primary and secondary power failure.

H. Power Supply:

1. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings. Each component of the fire alarm system requiring 120 VAC input power shall be served from a dedicated emergency branch circuit. Provide two #12 conductors and one #12 ground in 3/4" conduit to a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Identify/label breaker and branch circuit in accordance with NFPA requirements and Specification Section 16195.

2. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all external audio-visual devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.

3. All power supplies shall be designed and installed to meet UL and NFPA requirements for power-limited operation on all external initiating and indicating circuits.

4. The power supply shall provide integral charger for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 15 minutes, plus 25% spare capacity for future devices.

I. Surge Protection:

1. The fire alarm control panel shall be furnished with an integral surge protection device (SPD). Refer to 16412. It may be installed in an external cabinet as recommended by the manufacturer. In any case, the SPD must be connected upstream of any fire alarm equipment connections through a disconnect switch using #12 conductors maintained as short and as straight as possible.

2. Any communications or signaling circuits associated with the fire alarm system, which leave or enter a facility, shall be provided with a surge protection device. The devices shall be as recommended by the fire alarm system manufacturer.

J. FIRUS Interface and System Outputs to FIRUS

1. The fire alarm system shall provide 12 SPDT relay outputs to FIRUS. All relay outputs for connection to FIRUS shall be listed or approved for use in off-premises signaling applications. Signals to be transmitted include:

   a. Common Fire Alarm
   b. Common Supervisory Alarm
   c. Common Trouble

2. General alarms shall be interfaced from the outputs at the fire alarm control panel. The individual descriptive message shall be via addressable relay modules.

3. FIRUS relay outputs shall be located in the fire alarm control panel.

4. Subcontractor shall provide a designated, conduit and wiring as needed between the fire alarm control panel and the FIRUS panel. Relay outputs shall be permanently labeled in the fire alarm control panel with engraved plastic placards; “FIRUS-FIRE ALARM”, “FIRUS-COMMON SUPERVISORY”, and “FIRUS-COMMON TROUBLE”, respectively.

K. Terminations by Fermilab

1. All terminations to FIRUS will be made by Fermilab.

2. Testing of the FIRUS connection to verify proper outputs from the fire alarm system is part of this subcontract.

L. Communication:

1. The Digitized Voice Communication shall contain all equipment required for all audio control, signaling, and supervisory functions. This shall include digital voice units, speaker zone indication, and microphones.

2. Function: System perform the following functions:

   a. Operate as a supervised automatic digitized voice evacuation system.

b. Audibly and visually annunciate the active or trouble condition of every signal circuit.

c. Audibly and visually annunciate any trouble condition of tone generators and digital voice units required for normal operation of the system.

d. Provide all-call activities through activation of a single control switch.

e. Provide automatic, digitally recorded voice messages and tones.

3. Audio Amplifiers:

a. The audio amplifiers will provide a single channel audio power at 25 volts RMS for distribution to speaker circuits.

b. The audio amplifier shall include an integral power supply, and shall provide the following controls and indicators:

1) Normal Audio Level LED
2) Incorrect Audio Level LED
3) Brownout LED
4) Battery Trouble LED
5) Amplifier Trouble LED
6) Audio Amplifier Gain Adjust

c. Includes audio input and amplified output supervision backup input.

4. Audio Message Generator (Digitized Voice):

a. Each initiating zone or intelligent device shall interface with an emergency voice communication system capable of transmitting a digitized voice message to all speakers in the building.

b. Actuation of any alarm initiating device shall cause a digitized message to sound over the speakers. The message shall be repeated four (4) times.

c. A built-in microphone shall be provided to allow paging through speaker circuits.

d. The audio message generator shall have the following controls and indicators to allow for proper operator understanding and control:

1) All Call LED
2) On-Line LED
3) All Call Switch
4) Local Speaker Volume Control
5) Local (Test) Speaker

5. Voice Messages:

   a. A pre-programmed custom digital voice message shall be used for notification appliance speaker circuits. The messages shall be approved by Fermilab. Voice messages shall be from a female voice.

   b. Message shall be preceded by a tone and message shall be repeated four times until silenced.

   c. Messages shall be annunciated by a single channel in all evacuation signal zones throughout the building.

   d. Message shall be coordinated with Fermilab

2.3 INTERFACE WITH FERMILAB SITE WIDE EMERGENCY VOICE SYSTEM

A. FACP shall be able to interface with Fermilab's site wide emergency voice warnings system. Provide all necessary hardware and programming for complete and functional system.

2.4 SIGNALING LINE CIRCUIT DEVICES

A. Smoke Detectors:

1. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

2. Each smoke detector shall connect directly to an SLC loop.

3. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided. Provide a two-piece head/base design.

4. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

5. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided. Provide a remote LED indicator device if detector is not visible from a floor standing position.

6. A test means shall be provided to simulate an alarm condition.

7. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32ºF and 120ºF.

B. Manual Pull Stations:

1. Manual stations shall match the description on the drawings (refer to the General Electrical Equipment Schedule). The stations shall be mounted where shown on the drawings and be provided with all necessary mounting hardware.

2. Addressable, single action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering.

3. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.

4. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32ºF and 120ºF.

C. Monitor Modules:

1. Monitor Module shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit. It shall interface initiating devices with the control panel using Style D or Style B circuits. Subcontractor option: Use an interface module (2-wire operation) for Style B circuits connected to normally-open dry contacts, such as a flow switch.

2. The module shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being monitored, or where shown on the drawings. All mounting hardware shall be provided.

3. The module shall supply the required power to operate the monitored device(s).

4. The module shall provide address setting means using rotary decimal or DIP switches.

D. Addressable Relays:

1. Relay that represents an addressable control point used primarily for the control of auxiliary devices as indicated on the drawings. Subcontractor to provide additional slave relay(s), as required, rated for the electrical load being controlled (subcontractor to match voltage, amps, etc.).

2. Relay shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit.

3. The relay shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being controlled, unless otherwise shown on the drawings. All mounting hardware shall be provided.

4. The relay shall supply 24 VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

2.5 NOTIFICATION APPLIANCE DEVICES

A. Device Color:

1. Wall Mounted: Red housing with white lettering or pictogram.

B. Visual Notification Device - Emergency Communication Systems:

1. High intensity xenon strobe or equivalent shall have a clear lens for fire alarm annunciation strobe. Candela rating shall be visible from exterior of the device.

a. Candela ratings: V1=15, V3=30, V7=75, VH=110, VS=177.

2. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40%. The flash rate shall be 1 Hz. Where more than two strobes are visible from any one location, the fire alarm visual devices shall be synchronized.

3. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

C. Audio (Speaker) Alarm Devices - Wall Mounted:

1. Sound rating shall be dependent on the tap (wattage) setting. Tap settings shall be available in 3 dBA increments. A minimum of four (4) tap settings should be available to allow field adjustment of the sound output across a minimum range of 78 to 87 dBA, 400Hz to 4KHz (6 dBA cutoff) frequency range.

2. Speakers shall operate on a 25V RMS system, unless otherwise noted on drawings.

3. Speakers shall clearly reproduce a signal consisting of a live or prerecorded human voice with voice intelligibility.

4. Speaker, housing, and backbox shall be UL listed for fire alarm/emergency applications.

D. Combination Audio (Voice) and Visual Notification Device:

1. Wall mounted.

2. Combine speaker and visual components into a single device. Refer to the corresponding paragraphs above for requirements of each component.

2.6 ANNUNCIATION

A. LCD Annunciators:

1. Auxiliary annunciators shall indicate alarm and trouble conditions visually and audibly as shown on the drawings. Provide local TROUBLE ACKNOWLEDGE, TEST, and ALARM SILENCE capability. Minimum 80-character display.

2.7 CONNECTIONS TO AUXILIARY DEVICES PROVIDED BY OTHERS

A. Flow Switch:

1. Connection to flow switch to monitor fire protection flow switch or discharge output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed and MC; wired by EC.

B. Monitor Switch:

1. Connection to monitor switch to monitor fire protection system supervisory switches or output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.

2.8 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Subcontractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with NFPA 70, Article 760 for power-limited fire alarm signal service.

B. Approved manufacturers of fire alarm cable:

1. Comtran Corp.
2. Helix/HiTemp Cables, Inc.
3. Rockbestos-Suprenant Cable Corp.
4. West Penn Wire/CDT.

PART 3 - EXECUTION

3.1 SEQUENCES OF FIRE ALARM OPERATION

A. General:

1. Refer to the Fire Alarm Operation Matrix on the drawings for basic requirements and system operation.

2. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

B. Panel/Annunciator Alarm, Trouble, Supervisory Indication:

1. Appropriate system Alarm, Trouble, or Supervisory LED shall flash at the control panel, transponder, and annunciator locations.

2. The LCD display shall indicate all information associated with the condition, including the name of the item, type of device and its location within the protected premises.

3. Transmit the appropriate signal (supervisory, trouble, alarm) to the FIRUS system.

C. AHU Shutdown Sequence:

1. The fire alarm system shall utilize addressable relays to de-energize all AHU motor controllers. Coordinate other requirements with HVAC installer.

2. The fire alarm system shall directly shut down the AHU through the local HVAC control device (i.e., variable frequency drive or motor starter).

3.2 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Fire Alarm Control Panel:

1. Install the control panel where shown on the drawings.

2. All expansion compartments, if required, shall be located at the control panel.

C. Devices:

1. General:

a. All devices shall be coordinated with luminaires, diffusers, sprinkler heads, piping and other obstructions to maintain a neat and operable installation. Mounting locations and spacing shall not exceed the requirements of NFPA 72.

b. The location of all fire alarm devices shall be coordinated with other devices mounted in the proximity. Where a conflict arises with other items or with architectural elements that will not allow the device to be mounted at the location or height shown, the Subcontractor shall notify Fermilab to coordinate a different acceptable location.

2. Per the requirements of NFPA, detector heads shall not be installed until after the final construction cleaning unless required by Fermilab. If detector heads must be installed prior to final cleaning (for partial occupancy, to monitor finished areas or as otherwise required by

Fermilab), they shall not be installed until after the fire alarm panel is installed, with wires terminated, ready for operation. Any detector head installed prior to the final construction cleaning shall be removed and cleaned prior to closeout.

3. Manual Pull Stations:

   a. Stations shall be located where shown and at the height noted on the drawings.

4. Addressable Relays and Monitor Modules:

   a. Modules shall be located as near to the respective monitor or control devices as possible, unless otherwise indicated on the drawings.

   b. All modules shall be mounted in or on a junction box in an accessible location.

5. Notification Appliance Devices:

   a. Devices shall be located where shown on the drawings.

   b. Wall-mounted audio, visual and audio/visual alarm devices shall be mounted as denoted on the drawings.

D. Wiring:

1. Fire alarm wiring/cabling shall be provided by the Subcontractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.

2. Wiring shall be installed in minimum 3/4" IMC conduit.

3. All junction boxes shall be painted red with SLC and NAC circuits identified on cover.

4. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 16120.

5. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

   a. Fire alarm temporal audible notification for all audio appliances.

   b. Synchronization of all visual devices where two or more devices are visible from the same location.

   c. Ability to silence audible alarm while maintaining visual device operation.

6. Notification Appliance Circuits shall not span floors.

7. Signal line circuits connecting devices shall not span floors.

8. Signal line circuits connecting devices shall be provided with an isolation module at each floor separation or as otherwise shown on the drawings.

9. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with “E-Z Markers” or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

E. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows, or using colored tape at each conductor termination and in each junction box.

1. Power branch circuit conductors: In accordance with Section 16195.
2. Signaling line circuit: Overall red jacket with black and red conductors.
3. DC power supply circuit: Overall red jacket with violet and brown conductors.
4. Notification appliance circuit: Overall red jacket with blue and white conductors.
5. Door release circuit: Gray conductors.
6. Central station trip circuit: Orange conductors.
7. Central station fire alarm loop: Black and white conductors.

F. Devices surface mounted shall be mounted on surface backboxes furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, shall be the same shape and size as the device shall not have visible knockouts.

G. Make conduit and wiring connections to door release devices, sprinkler flow and pressure switches, sprinkler valve monitor switches, fire suppression system control panels, duct analog smoke detectors and all other system devices shown or noted on the Contract Documents or required in the manufacturer's product data and shop drawings.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 16010.

B. Test in accordance with NFPA 72, Chapter 14 and local fire department requirements. Submit documentation with O & M manuals in accordance with Section 14.6 of the Code.

C. Subcontractor shall test and adjust the voice fire alarm system as follows:

1. Speaker taps shall be adjusted to the lowest tap setting which achieves a sound level higher than or equal to the greatest of the following:

a. 70dBA.

b. 15 dBA above ambient levels as indicated in NFPA 72 Table A.18.4.3.

c. 15 dBA above measured ambient. 5 dBA above the maximum measured sound level with duration of more than 60 seconds.

d. As specified on the drawings.

2. Sound level measurement procedure shall meet the following requirements:

a. All measurements shall use the 'A' weighted, dBA, sound measurement scale.

b. All measurements shall be taken after furnishings, wall coverings and floor coverings are in place.

c. All measurements shall be taken after fixed equipment (HVAC units, etc) producing ambient noise is installed and is in operation.

d. All sound level measurements shall be taken at a height of 5' above the finished floor level.

e. Measurements shall be taken in every unique room. If there are multiple rooms, which have the identical dimensions and function, 10%, or a minimum of 2 rooms shall be tested. The results from the rooms tested shall be averaged and the remaining rooms may be adjusted per the average.

f. Measurements shall be taken on a 20' x 20' grid and the results for all points taken shall be averaged. If the room is smaller than 20' x 20' a minimum of two measurements are required.

g. Measurements shall be taken halfway between speakers or halfway between a speaker and the wall. No measurements shall be taken at the extreme edges of the room, nor directly under speakers.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 16010.

B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

C. Note that room numbers depicted on the drawings will not necessarily reflect the actual room (signage) numbers that the Fermilab selects. The Subcontractor and fire alarm manufacturer shall coordinate the actual room numbers as the Fermilab directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at the project closeout.

3.5 SYSTEM TRAINING

A. System training shall be performed under provisions of Section 16010.

B. Minimum on-site training shall be (4) hours:

END OF SECTION 16721

SECTION 16722 - AIR SAMPLING SMOKE DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air Sampling Smoke Detector
B. Piping Network

1.2 REFERENCES

A. NFPA 72 - National Fire Alarm Code

B. NFPA 101 - Life Safety Code

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.

B. Provide product data showing the type, size, rating, style, catalog number, manufacturers' names, photos, and/or catalog data sheets for all items to ensure compliance with these specifications.

C. Submit CAD shop drawings of the complete layout of the entire system, showing wiring and all equipment. The CAD wiring diagram shall be submitted as a shop drawing. Reproduction of contract drawings is not acceptable.

D. Provide shop drawings indicating air sampling network piping, routing of piping, sizes of piping, sample point locations and sizes, and system components.

E. All air sampling pipe routing must be submitted to and approved by the Fermilab. The routing must be coordinated with mechanical ductwork. Obtain a shop drawing of mechanical ductwork for coordination purposes from the Mechanical Subcontractor.

F. Provide manufacturer's installation directions.

G. Submit sequence of operation and verification of operation by manufacturer.

H. Provide installation and maintenance manuals under provisions of Section 16010.

I. Submit manufacturer's certificate that system meets or exceeds specified requirements.

J. Provide information on the system batteries as follows:

1. Total battery capacity
2. Total capacity used by all devices on this project
3. Total available future capacity.

K. Provide piping calculations as generated by Vision Systems' Aspire software.

L. All shop drawings and system calculations shall be submitted to the following:

1. Fermilab for review and approval.

M. Submit graphical map layout.

1.4 EXTRA MATERIALS

A. Provide spare parts under provisions of Section 16010.

B. Provide two (2) filters of each type used on this project.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 16010.

B. Store and protect products under provisions of Section 16010.

1.6 REGULATORY REQUIREMENTS

A. System: UL and FM listed.

B. Conform to requirements of NFPA 10

C. Conform to requirements of Americans with Disabilities Act (ADA)

1.7 SYSTEM DESCRIPTION

A. Smoke Detection System: Type; air sampling with CPVC piping and sampling points with laser type detector.

B. The system shall include, but not be limited to, detector assemblies, remote display units, power supplies, batteries, air pipe sampling network, and necessary hardware and interface to building fire alarm system.

C. System Supervision: Provide an electronically-supervised system, with supervised communications between detectors and to a computerized head-end system.

D. Detectors shall communicate directly with addressable fire alarm control panel for annunciation and notification by activating horns and strobe lights.

E. Extent of ASSD system work is shown on drawings. The equipment supplier shall be responsible for a complete and operational system including but not limited to ceiling level detection, air sampling detector, power supplies, battery packs, enclosures, programming software and graphical user interface software.

F. Provide all sampling pipes and fittings and install all other associated equipment and devices to properly install sampling pipe.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in fire detection and fire alarm systems with five (5) years documented experience.

B. Installer/Supplier:

1. Company specializing in fire detection and fire alarm systems with five (5) years documented experience.

2. Company with certified factory trained personnel. Installers must be certified for design of complete system by the system manufacturer.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 16010.

B. Provide a CAD drawing of each area of the building, at a maximum sheet size of 11" x 17" showing each device on the project. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 16010.

B. Include operating instructions and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer’s representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

1.11 WARRANTY

A. Provide one (1) year warranty on all materials and labor.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As shown on fire alarm drawings.

2.2 AIR SAMPLING SMOKE DETECTION SYSTEM EQUIPMENT

A. Detector Control Panel: Modular construction with surface wall-mounted enclosure capable of programming and displaying obscuration rates detected within unit, identify trouble and alarm signals, and provide for testing of detector. The number of detectors shown on the drawings is for informational purposes

only. The actual number of detectors required shall be as determined by the system calculations.

1. Provide one display module in front of enclosure for each piping network.

2. Provide programming module in front of enclosure.

3. Provide scanner module to differentiate at which input pipe an alarm condition occurs. Scanner shall be capable of monitoring four separate pipe inputs.

4. Power Supply:

   a. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings.

   b. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all communication devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.

5. The detector shall have programmable sensitivity ranges from 0.0015%/ft to 0.12%/ft.

6. The detector shall be approved and listed to provide up to 20,000 square feet of protection.

B. Detector Display Panel: Modular construction with surface wall-mounted enclosure. Be capable of displaying obscuration rates detected within unit, and identify trouble and alarm signals.

1. Provide display module in front of enclosure for each number of new detectors provided.

2. Power Supply:

   a. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings.

   b. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all communication devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.

   c. The power supply shall provide integral charger for use with internal batteries sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 10 minutes.

C. Interface:

1. Provide the necessary hardware to interface all detectors and display units.

2. Provide necessary interface contacts to the addressable fire alarm control panel for notification purposes. The Installing Subcontractor shall provide conduit, wire, and terminations.

D. Piping Network:

1. The detector locations shall be as shown on the systems drawings. The system supplier shall determine exact quantities of detectors. Alternate locations may be considered based on information from the system supplier after the suppler is selected.

2. The network shall consist of sampling pipe and all associated elbows, tees and end caps as required. Sampling points shall be pre-drilled prior to installation at locations determined by system calculations.

3. The transport time from the farthest sampling point to the detector shall not exceed 60 seconds.

E. Piping Materials:

1. The sampling pipe shall consist of post chlorinated polyvinyl chloride (CPVC) material. The use of EMT conduit, copper tubing or PVC products are not permitted.

2. The size of the sampling pipe shall be 1/2 inch, 3/4 inch, or 1 inch nominal inside diameter as determined by the system calculations. Pipe sizes shall be determined by the system manufacturer. Calculations shall be submitted with shop drawings.

3. Acceptable Manufacturers:

   a. Blaze Master as manufactured by B. F. Goodrich Co.
   b. Flameaway as manufactured by Grinnell Co.
   c. VESDA pipe as manufactured by Vision Systems Inc.

4. The color of all material shall be orange.

5. Painting of sampling pipe is prohibited.

6. Pipe shall meet or exceed the requirements of ASTM F442 in standard dimension ratio 15.

7. Fittings shall meet or exceed the requirements of ASTM F437, ASTM F438 and ASTM F439 for Schedule 80 threaded, Schedule 40 socketed and Schedule 80 socketed, respectively.

8. All socket type joints shall use primers and solvent cements. Primers and solvents shall be listed by the National Sanitation Foundation (NSF) for use with potable water and be approved by the CPVC manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Detector Control Panel:

1. Install control panel and remote display unit where shown on the drawings.

2. All expansion compartments, if required, shall be located at the control panel.

3. Detachable airtight connects shall be used at the detector enclosure. The sampling pipe shall terminate within 18 inches of the detectors inlet openings and be mechanically fastened to the building. The sampling pipe shall then be connected to the detector by a piece of flexible clear vinyl tubing, not exceeding 24 inches in length, with the same internal diameter as the sampling pipe. The sampling pipe and air tube shall be equipped with detachable couplings.

C. Piping at Ceiling Level:

1. Piping shall be supported with mechanical pipe hangers attached to the structure of the building. Attaching sampling pipes to cable trays, ‘Superbars’, ductwork, telecommunications equipment, light fixtures, etc., is strictly prohibited.

2. Hangers and fasteners must be of the appropriate size for supporting the piping without distorting the pipes.

3. The use of non-mechanical hangers or fasteners, such as adhesives, is prohibited.

4. Piping shall be installed as close as practical to structural ceiling. Coordinate installation with mechanical ductwork shop drawings prior to installation of any piping.

5. Piping shall be clearly labeled with adhesive labels every five feet. Labels shall be facing downward and be visible from the floor level.

6. Parallel sampling pipes shall be no more than 30 feet apart.

7. Sampling points shall be drilled directly into the pipe and be directed downward. They shall be within 6 inches of the underside of the ceiling above.

8. Sampling points shall be clearly marked with a wrap-around label.

9. Sampling points shall not be more than 10 feet apart. Sampling points located closest to walls shall not be greater than 12 feet from the wall, or half the distance between columns, whichever is less.

10. All areas shall be covered by sampling points including alcoves, ceiling cavities, etc.

11. All sampling points shall be located so they are more than 12 inches above any horizontal obstruction such as ductwork or cable tray, that is located directly below the sampling point, and are three feet clear of all supply air registers and/or air flows.

12. All branch lines shall have a threaded removable end cap for maintenance back flushing of the system.

13. All sampling pipe shall be cleaned inside and outside and joined together using approved methods and materials.

14. Painting of sampling pipe is prohibited.

D. Software and Hardware:

1. The equipment supplier shall provide programming in the graphical user interface software to show a graphical display of the floor, detector location, and piping layout. The screens shall also mimic the display panel located on the detector.

E. Graphic Air Sampling Smoke Detection Map:

1. A graphical map of the air sampling smoke detection system shall be provided and placed at each detector and display unit, whether new or existing.

2. The map shall be a full color image on an 11"x17" background. The background shall be white and mounted on a rigid backing.

3. The graphic shall be laminated with an ultraviolet inhibitor.

4. Provide a clear, anti-glare LEXAN panel cover.

5. The entire graphic shall be housed in an aluminum frame.

6. Mount graphic adjacent to each detector.

7. The graphic shall include, but not be limited to, the following:

   a. Detection area outlined for each detector.
   b. Walls, doors, room names and room numbers.
   c. Locations of fire alarm control panels.
   d. Locations of detectors.
   e. Locations of all piping networks.

f. Routing of air sampling pipes and sampling point locations.
g. HVAC unit designations and return air grille locations.
h. North reference arrow.
i. A 'YOU ARE HERE' arrow for each map.
j. Legend of devices and other symbols.

F. Testing:

1. Provide testing of the ASSD system.

2. Installing Subcontractor and equipment supplier shall be present.

3. Fermilab shall be notified 72 hours in advance of commissioning of system and may attend.

4. The following tests shall be performed, documented, and submitted to the Fermilab for review:

a. Suction Pressure Test:

1) At approximately 25% of the sampling holes the suction shall be measured using a magnahelic gage. The measured result shall be compared with the design calculations. If the measure suction deviates by more than 10%, the cause of the deviation shall be determined and corrected before the system is considered acceptable.
2) The minimum permissible suction pressure shall not be less that 0.01 inches of water.
3) At lease two sampling points shall be tested in each pipe.
4) Each pipe shall have the nearest sampling point and the farthest sampling point tested.

b. Smoke Transportation Time:

1) The furthest sampling point in each pipe run shall be tested and its transportation time recorded until the detector indicate at least 20% above the normal levels.
2) The maximum permissible transportation time shall not exceed 60 seconds.
3) The transportation time shall not deviate by more than 10% from the design calculations. If the measure transportation time deviates by more than 10%, the cause of the deviation shall be determined and corrected before the system is considered acceptable.

c. After the system has been in operation for (1) week, the system thresholds and ambient contaminations levels shall be reviewed and adjusted to ensure no false alarms occur.

5. The Subcontractor shall coordinate the testing of each ASSD system with the fire department and submit a certification that each detector is

operating properly and that all control panels, annunciators, and remote indicators are correctly indicating the device.

G. Building Fire Alarm Interface:

1. Provide dry contacts to notify the addressable building fire alarm system for the following:

a. Fire
b. Trouble
c. Low Battery Voltage

H. FIRUS Interface

1. Provide interface to Fermilab FIRUS System for the following

a. Trouble
b. Battery Trouble

3.2 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed under provisions of Section 16010.

B. Test in accordance with NFPA 72 and local fire department requirements.

C. Make connections to control panels under the supervision of the equipment supplier.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 16010.

B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

C. Note that room numbers depicted on the architectural/engineering drawings will not necessarily reflect the actual room (signage) numbers that Fermilab selects. The subcontractor and fire alarm manufacturer shall coordinate the actual room numbers that Fermilab directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at project closeout.

3.4 FIRE ALARM WIRE AND CABLE COLOR CODE

A. As specified by the ASSD system manufacturer.

B. Power Branch Circuit Conductors: As specified in Section 16195.

C. Install wiring in raceways.

D. Install wires and cables without splices. Make connections at equipment terminals or on terminal strips mounted in enclosures of adequate size.

3.5 ZONE SCHEDULE

A. As scheduled on the drawings.

END OF SECTION 16722

SECTION 16950 - TESTING ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section prescribes the basic minimum requirements for field testing and inspection of electrical equipment and work.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to previous Sections which describe items of related Work. Coordinate Work prescribed by this Section with Work prescribed in previous sections.

1.3 RELATED TECHICAL REQUIREMENTS

A. Project sections.

B. Subcontract drawings.

C. Manufacturer's instruction manuals, drawings, and information applicable to the apparatus, equipment and systems.

1.4 RELATED WORK

A. Examine all portions of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

PART 2 - CONDITIONS

2.1 GENERAL

A. The work of this section is subject to the Fermilab Construction Subcontract Terms and Conditions and to Exhibit A, SCHEDULE AND SUPPLEMENTARY TERMS AND CONDITIONS.

2.2 APPLICABLE STANDARDS

A. The publications listed below form part of this Section. Each publication shall be the latest revision and addendum in effect on the date of subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein or the details on the drawings, the Work included under this Section shall conform to the provisions of these publications:

1. ANSI (American National Standards Institute):

   a. ANSI/IEE 400 Guide for Making High Direct Voltage Tests on Power Cable Systems in the Field.

2. IEEE (Institute of Electrical and Electronics Engineers).

3. NEMA (National Electrical Manufacturers Association).

4. NETA (National Electrical Testing Association).

PART 3 - EXECUTION

3.1 GENERAL

A. This Section provides guidelines for the inspection, testing, and checkout of the electrical systems to ensure that the electrical installation is in accordance with the design sections, drawings, and manufacturer's instructions.

B. The listings and descriptions of the inspections, tests, and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests may be necessary throughout the course of the Work.

C. Medium voltage cable testing shall be performed by an independent subcontractor in accordance with NETA (National Electrical Testing Association).

1. Independent testing subcontractor will be selected and supervised by Fermilab and paid by the Subcontractor.

2. Coordination of cable testing shall be arranged under this subcontract (cable installation subcontract) to provide Fermilab and testing subcontractor with ample time and notice. Cable installation subcontractor shall provide the Fermilab Construction Coordinator 24-hours notice of time and period available for cable testing.

3. Cable installation subcontractor shall provide a knowledgeable workman to be present at all times during the cable testing. Workman's duties and responsibilities shall include, but not be limited to, verification of cables to be tested, removal of end boots or seals, verification of all safety precautions, keeping manholes free from water and acting as subcontractor's representative for verification of cable test results.

4. Independent cable testing subcontractor is responsible for hi-pot testing as cables (only) as described on Form #65F1104, attached.

5. All other testing and reporting as described herein shall be the responsibility of the cable installation subcontractor.

D. The checks and tests shall be documented on the attached Quality Control Forms. Quality Control Forms shall be available for Fermilab review at any time during the Subcontract. Completed Quality Control Forms shall be given to the Fermilab Construction Coordinator at the conclusion of the Subcontract.

E. Subcontractor shall be responsible for all inspection and test activities. The detail implementation plan shall be reviewed and approved by the Fermilab Construction Coordinator.

F. Equipment or circuitry shall not be energized, de-energized, or tied-in to a system without prior review and approval of the test plan and procedure, prepared and submitted by the Subcontractor.

3.2 TESTING AND INSPECTION OF EQUIPMENT AND CABLE

A. Preparation:

1. A detailed plan and schedule shall be prepared for inspection and testing activities.

2. Manufacturer, make, model, serial numbers, and dates of latest calibration of the instruments used shall be recorded on the test forms.

3. Testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress, and for ensuring that important facts and questionable data are reported.

4. The test supervisor shall ensure that testing and checkout work is conducted in a safe manner. Special safety precautions such as the following shall be utilized:

   a. Lockout and tagout procedures.

   b. Barricades.

   c. De-energization or isolation of equipment before testing.

   d. Review of procedures with safety personnel.

   e. Erection of warning signs.

   f. Stationing of guards and watchmen.

   g. Maintenance of voice communications.

   h. Personnel orientation.

   i. Project Hazard Analysis and Job Hazard Analysis as required.

5. The test apparatus shall be of the proper voltage class and rating for the test being performed. Care shall be taken that the installation shall not be overstressed.

6. At any stage of construction and/or when electrical equipment or systems are determined to be damaged, faulty, or requiring repairs, the electrical equipment or systems shall be reported to the Fermilab Construction Coordinator. Corrective action may require prior approval.

3.3 INSPECTION AND TEST OF ELECTRICAL INSTALLATION

A. Additional inspections may be carried out by Fermilab. Fermilab inspection shall not alleviate the requirement for inspection as defined herein.

PART 4 - ATTACHMENTS

Attachment 6:
Form: 65F1300: Electrical Punch List Record

Attachment 7:
Form: 65F1200: Underground Conduit (Duct Bank) Inspection Checklist

Attachment 9: Form: 65F1202:	Aboveground Conduit Inspection Checklist
Attachment 10: Form: 65F1100:	Conduit Sealing Inspection Record
Attachment 12: Form: 65F1204:	Cable Pulling Inspection Checklist
Attachment 13: Form: 65F1101:	Insulation Resistance Test Record
Attachment 15: Form: 65F1205:	Medium and High Voltage Cable Termination Inspection Checklist
Attachment 16: Form: 65F1103:	Medium and High Voltage Cable Splice Inspection Record
Attachment 17: Form: 65F1104:	DC High Potential Test (Medium Voltage Cable) Test Record
Attachment 18: Form: 65F1105:	Ground/Earthing System (Grid or Loop Type System) Inspection Record
Attachment 21: Form: 65F1108:	Ground Continuity (Non-electrical Equipment/Structures) Test Record
Attachment 23: Form: 65F1110:	Panelboard Inspection Record
Attachment 42: Form: 65F1129:	Electric Motor Run-In Test Record

SECTION 16950
ATTACHMENT 6
FORM: 65F1300
ELECTRICAL PUNCH LIST RECORD

DATE:	REV.:	REF. DWG.:

Item No	Identification & Location	Remarks	Date Corrected	Supervisor's Approval

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 7
FORM: 65F1200
UNDERGROUND CONDUIT (DUCT BANK) INSPECTION CHECKLIST

DATE:	REV.:

NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF UNDERGROUND UTILITIES

1.	Trenching checked for location, elevation and forming. Check for conflicts with other construction.	
2.	Conduit size, type and location checked for conformance to Sections and drawings	
3.	Minimum concrete coverage will be in accordance with Sections on all sides of conduits.	
4.	Conduit spacing, supports and tie-downs correct.	
5	Stub-up dimensions and location checked.	
6.	Field bend radius correct in accordance with drawings/Section bends free of deformities.	
7.	Pipe caps on all ends	
8	All conduit connections tightly made.	
9	Reinforcing bars installed when specified.	
10.	All field changes recorded on as-built drawings	
11.	Trench or forms free of debris	
12.	Concrete coverage adequate, spacers not left exposed.	
13.	Concrete color in accordance with Sections.	
14.	Stub-up concrete encasement correct.	
15.	Backfill and compaction correct	
16.	Conduits free of such things as stoppages and grout leakage.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 9
FORM: 65F1202
ABOVEGROUND CONDUIT INSPECTION CHECKLIST

DATE:	REV.:

NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF CONDUIT

1	Supports and spacing in accordance with Sections, codes & drawings	
2.	Supports adjacent to terminal fittings.	
3.	Conduits clean, stub-ups protected, open ends plugged, damage during construction repaired	
4.	Field bend radius correct in accordance with Sections and codes. Bends free of deformities.	
5.	Expansion joints as required.	
6.	Installation neat and evenly spaced	
7.	Conduit permanently and effectively grounded, unless Sections permit otherwise. Bonding jumpers installed around inspection joints.	
8.	Proper fittings installed with threads fully engaged; no wrench cuts, conduit ends have bushings and covers installed	
9.	Drains installed in accordance with Sections.	
10.	RGS, PVC or PVC-coated conduit installed when specified on drawings	
11.	Flexible conduits installed with proper bending radius and with standard fittings.	
12.	Junction boxes leveled and supported with proper hubs, locknuts and bushings installed, in accordance with drawings. Junction boxes properly identified.	
13.	Adequate number of pulling points.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950

ATTACHMENT 10
FORM: 65F1100
CONDUIT SEALING INSPECTION RECORD

DATE:		REV:
BUILDING:	AREA/UNIT:	PANEL BOARD TAG:

NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF CONDUIT SEALS

1. Receiving Operations/Inspection complete.	
2. Equipment Protection Program instituted and documented.	
3. Check assembly for any missing parts.	
4. Enclosure approved for area classification.	
5. Panelboard circuit schedule filled out.	
6. Correct circuit breaker fuse size and location.	
7. Neutral wire correctly color-coded.	
8. Grounding/earthing installed and connected. Test Record, Form 000.265.F1109.	
9. Ground Continuity Test Record (Electrical Equipment & Ground Test Bars), completed.	
10. Seals installed (if required).	
11. Check for breather and drain.	
12. Check panel load balance.	
13. Check color-coding of branch circuit conductors.	
14. Clean out.	
15. Check mounting and supports.	
16. Fixtures and receptacles are correct type and installed as per drawings.	
17. Fixtures and receptacles on correct circuit.	
18. Nameplate, number of circuits and panelboard location per drawing.	
19. Correct glands installed (i.e., flameproof glands on explosion-proof enclosures.).	
20. Megger buses including neutral. Record results on Form 65F1124.	
21. Insulation Resistance (Equipment) Test Record. Main disconnect & outgoing circuits should be open.	
22. Equipment Protection Program completed and documented.	
23. Final inspection complete. Punch items on Form 65F1300, Electrical.	
24. Punch List Record, cleared.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 12
FORM: 65F1204
CABLE PULLING INSPECTION CHECKLIST

DATE:	REV.:	REF. DWG.:

NOTE: This Inspection Checklist shall be used for cable pulling in conduit and ducts.

1.	Check that conduit has been swabbed-out and any standing water removed.	
2.	Check that number of pulling points is adequate and the number of bends between pulling points does not exceed Section or code requirements.	
3.	Check cable reel assignments and cutting schedules.	
4.	Check cable voltage rating, minimum pulling temperature and type of pulling compound.	
5.	Inspect cables for jacket damage.	
6.	Ambient temperature within manufacturer's recommended installation limits.	
7.	Monitor pulling tension on critical pulls and verify that maximum permitted tension not exceeded in accordance with tension data.	
8.	Perform DC High Potential Test (hypot) on medium and high voltage cables (rated over 2000 volts) and record on Test Record, Form 65F1104, DC High Potential Test Record (Medium Voltage Cable).	
9.	Bend radius of trained cable is in accordance with Sections and cable is free of kinks.	
10.	Installation is neat and cable lay (maintained spacing) in accordance with Sections.	
11.	Cables identified in accordance with Sections and drawings.	
12.	Cable ends sealed after cutting.	
13.	Manhole grounding system installed.	
14.	Cable neutral conductors grounded.	
15.	Cables firewrapped in manholes.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 13
FORM: 65F1101
INSULATION RESISTANCE TEST RECORD

DATE:	REV.:

TEST EQUIPMENT: _____

TEST VOLTAGE: _____

AMBIENT TEMPERATURE: _____ º C _____ º F

Panel No. Feeder No. Circuit No.	Wire Tagging	Cable-rated Voltage	Quantity	Size	From	To	Insulation Resistance (Megaohms)	Initials

Cable-rated voltage (ohms) _____

Test duration _____

Resistance for cable quality _____

Cable/wire size or amperage (megaohms) _____

Resistance when cable connected to equipment _____

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 15
FORM: 65F1205
MEDIUM AND HIGH VOLTAGE CABLE TERMINATION INSPECTION CHECKLIST

DATE:	REV.:

NOTE: This Inspection Checklist shall be used for terminations rated greater than 2000 volts. Inspection Record

CIRCUIT NO.: _____ DWG.: _____

KIT MANUFACTURER: _____ KIT NO.: _____

		Check Item
1.	Cable size, type, location, installation and routing in accordance with drawings.	
2.	Bend radius in accordance with specifications and cable jacket free of kinks.	
3.	Cable termination supports and support spacing in accordance with drawings and specifications.	
4.	Installation neat and evenly spaced.	
5.	Cable free of surface damage.	
6.	Termination kit/materials installed in accordance with manufacturer's instructions.	
7.	Document DC High Potential Test (hypot) on Form 65.F1104, DC High Potential Test Record (Medium Voltage Cable), or obtain appropriate documentation from testing Subcontractor.	
8.	Cable terminated in accordance with equipment manufacturer's instructions including torquing of bolted connections.	
9.	Check phase location and marking: Left to Right, Top to Bottom, or Front to Rear, in accordance with specifications requirements. A. Acceptable _____ B. Acceptable _____ C. Acceptable _____	
10.	Metallic Sheaths/Shields/Armor grounded/earthed in accordance with manufacturers recommendations.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 16
FORM: 65F1103
MEDIUM AND HIGH VOLTAGE CABLE SPLICE INSPECTION TEST RECORD

DATE:	REV.:

NOTE: This Inspection Record shall be used for cables rated greater than 2000 volts. INITIAL/DATE

REFERENCE DWG. _____ SPLICE NO. _____

SPLICE KIT _____ MANUFACTURER _____

KIT NO _____ KIT NO _____

CIRCUIT NO _____

FROM _____ TO _____

CABLE RATED VOLTAGE _____ CABLE TYPE _____

1. Location _____

   Manhole Number _____

2. Splice Make-up: _____

   A. Acceptable _____

   B. Acceptable _____

   C. Acceptable _____

   Neutral Acceptable _____

3. Document DC High Potential Test (hypot) on Form 65F1104, DC High Potential. _____

   Test Record (Medium voltage Cable), or obtain appropriate documentation from testing Subcontractor.

4. Sheath grounded/earthed, as required _____

5. Field changes recorded on as-built drawings. _____

6. Splice markers installed. _____

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950

ATTACHMENT 17

FORM: 66F1104

DC HIGH POTENTIAL TEST (MEDIUM VOLTAGE CABLE) TEST RECORD

DATE:	REV.:

CIRCUIT NUMBER: _____ REF DWG.: _____

CABLE SIZE: _____ (SQMM) _____ (MCM)FROM: _____ TO: _____

NUMBER OF CONDUCTORS: _____ NUMBER OF SPLICES: _____

CABLE LENGTH _____ MANUFACTURER: _____

INSULATION TYPE: _____ THICKNESS: _____

JACKETMATERIAL: _____

WEATHER: _____ TEMP: _____ º C _____ º F HUMIDITY: _____ %DATE: _____

TEST EQUIPMENT USED: _____

NOTES:

1. The test voltage shown below shall be reached in 10 equal voltage increments.

2. After each voltage increase, the leakage current shall be allowed to stabilize during a 1 minute interval. If 1 minute intervals are insufficient to stabilize the current, the cable shall be discharged, and the test repeated with new time intervals of greater, but still equal duration

3. Record the stabilized leakage current, in microamps, at the end of each time interval.

4. Allow the voltage to remain constant at the full test voltage and record the leakage current for 5 minutes for unshielded cables and 15 minutes for shielded cables.

5. Read test equipment instruction manual prior to testing cable

6. When Project specifies the plotting of test results, attach 2ND sheet with separate plot for each phase. Note leakage current, in microamps, on “y” axis. Note step-voltage increase on “x” axis, followed by time, in minutes, for the dielectric absorption portion of the test.

7. All other phases and shields to be grounded.

Voltage Hold Time

At Each Step:

sec	Kv	Kv	Kv	Kv	Kv	Kv	Kv	Kv	Kv
∅A									
∅B									
∅C									

Time At Kv	sec 30	min 1	min 2	min 3	min 4	min 5	min 6	min 7	min 8	min 9	min 10	min 11	min 12	min 13	min 14	min 15

CABLE RATED VOLTAGE (kilovolts) TEST VOLTAGE (kilovolts)

Tester's Initials Date

DISTRIBUTION SUBCONTRACTOR/DATE

SECTION 16950
ATTACHMENT 18
FORM: 65F1105
GROUNDING/EARTHING SYSTEM INSPECTION RECORD
(GRID OR LOOP-TYPE SYSTEM)

DATE:	REV.:	REF. DWG.:

NOTE: This Inspection Checklist shall be used for installation and checking of Main Grounding/Earthing System.

1. Primary conductor is correct size and type in accordance with drawings.	
2. Ground/earthing conductor burial depth and routing per drawings and Sections.	
3. Thermal/compression connections checked (no cold joints or burn-outs).	
4. Thermal/compression connection insulation checked.	
5. Ground/earthing anode locations and installation per drawing.	
6. Ground/earthing anode connections checked.	
7. Location, type, size and insulation color of equipment taps per drawings and protected during construction.	
8. System ground/earthing anode resistance-to-earth checked and recorded on Form 65F1106, Ground/Earthing Anode Testing Test Record (Attachment 19).	
9. All field Revisions recorded on as-built drawings.	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 21
FORM: 65F1108
GROUNDING CONTINUITY TEST RECORD
(NON-ELECTRICAL EQUIPMENT/STRUCTURES)

DATE:	REV.:	REF. DWG.:

TEST EQUIPMENT
USED: _____ WEATHER: _____

1.3

Equipment Tag No. Or Structure	Drawing	Measured Resistance (ohms)	Initials & Date

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 23
FORM: 65F1110
PANELBOARD INSPECTION RECORD

DATE:		REV.:
BUILDING:	AREA/UNIT:	PANEL BOARD TAG:

1.	Receiving Operations/Inspection complete.	
2.	Check assembly for any missing parts.	
3.	Enclosure approved for area of installation.	
4.	Panelboard circuit schedule filled out.	
5.	Correct circuit breaker and location. Verify exact model number and rating of each conduit breaker matches submitted shop drawings. Update shop and record drawings as needed.	
6.	Neutral and phase conductors correctly color-coded.	
7.	Grounding/earthing installed and connected. Test Record, (Form 54F1109, Attachment 22) Ground Continuity Test Record (Electrical Equipment and Ground Test Bars), completed.	
8.	Check panel load balance.	
9.	Check color-coding of branch circuit conductors.	
10.	Clean out.	
11.	Check mounting and supports.	
12.	Fixtures and receptacles are correct type and installed as per drawings.	
13.	Fixtures and receptacles on correct circuit.	
14.	Nameplate, number of circuits and panelboard location per drawing.	
15.	Megger buses (including neutral). Record results on Form 65F1124 (Attachment 37), Insulation Resistance (Equipment) Test Record. Main disconnect and outgoing circuits should be open.	
16.	Final inspection complete. Punch items on Form 65F1300, Electrical Punch List Record, cleared	

DISTRIBUTION SUBCONTRACTOR/DATE _____

SECTION 16950
ATTACHMENT 42
FORM: 65F1129
ELECTRIC MOTOR RUN-IN TEST RECORD

DATE:	REV.:
MOTOR TAG NO.:	TEST EQUIPMENT:
REF. DWG.:	

Notes:
1. Duration of tests to comply with Subcontract Selections.
2. Complete Form 65F1127, Electric Motor – Electrical Activities Inspection Record, prior to energizing motor.

TEST	REMARKS	INITIALS/DATE
RESISTANCE (in ohms): Bonding resistance measured from motor frame to Main ground/earth system tap. _____		
VOLTAGE (in volts): Actual voltage measured at Motor Control Center _____		
ROTATION CHECK: Bump motor to verify rotation. Motor shall be Uncoupled.		
NO LOAD CURRENT (in aamps): At beginning of test: _____ At end of test: _____		
TEMPERATURE OF BEARING: Check bearing for high temperature: Before start: _____ 15 minutes after start: _____ 30 minutes after start: _____ 1 hour after start: _____ 2 hours after start: _____ 3hours after start: _____		
VIBRATION: Make visual inspection during run-test. Record any unusual vibration in remarks column.		
NOISE: Record any unusual noise in remarks column.		

DISTRIBUTION SUBCONTRACTOR/DATE _____

END OF SECTION 16950

SECTION 16995 - COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Responsibilities
C. Related Work
D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 16 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to specification section 01810.

C. Commissioning requires the participation of Division 16 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01810. Division 16 Contractor shall be familiar with all parts of Section 01810 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of specification section 01810.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section.

1. Commissioning Plan (Cx Plan)
2. Section 15995 - Commissioning of Mechanical
3. Section 16570 - Lighting Control Systems

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Test equipment required for NETA Acceptance Testing.

2. Light meter.

3. Sound level meter.

4. Digital multimeter capable of measuring voltage (AC/DC), current, and resistance.

5. Power quality and energy analyzer capable of capturing waveform (3 phase) and data recording

6. Handheld thermal imaging camera.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01810 for additional Division 16 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of specification section 01810.

END OF SECTION 16995

SECTION 17010 - BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Communications Systems Requirements specifically applicable to Division 17 sections, in addition to Division 1 - General Requirements.

1.2 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the Communications Systems as shown on the drawings and specified herein.

B. Each Subcontractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make their portion of the Communications Systems a finished and working system.

C. Description of Systems include but are not limited to the following:

1. Complete Structured Cabling System including, but not limited to:

a. Telecommunication Room equipment including cable management.

b. Cabling Pathway.

c. Grounding and Bonding.

1.3 WORK SEQUENCE

A. All construction work that will produce excessive noise levels and interference with normal building operations, as determined by Fermilab, shall be scheduled with Fermilab. It may be necessary to schedule such work during non-occupied hours. Fermilab shall reserve the right to set policy as to when restricted construction hours will be required.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5” and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, ladder rack, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The subcontractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The subcontractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One subcontractor shall be designated as the Coordinating Subcontractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Subcontractor for this project shall be the Mechanical Subcontractor.

a. The Coordinating Subcontractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Subcontractor for addition of work by other trades. KJWW will provide electronic file copies of ventilation drawings for subcontractor’s use if the subcontractor signs and returns an “Electronic File Transfer” waiver provided by KJWW. KJWW will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all subcontractors participating in the coordination process and Fermilab.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1 '-0" (minimum).

2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Fermilab's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each subcontractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The subcontractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The subcontractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and Fermilab's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to Fermilab.

10. Complete the coordination drawing process and obtain sign off of the drawings by all subcontractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the subcontractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.5 QUALITY ASSURANCE

A. Telecommunications Structured Cabling System Standards:

1. All work and equipment shall conform to the most current ratified version of the following published standards unless otherwise indicated that draft standards are to be followed:

   a. ANSI/NECA/BICSI 568 - Standard for Installing Commercial Building Telecommunications Cabling

   b. ANSI/TIA-568-C.0 - Generic Telecommunications Cabling for Customer Premises

   c. ANSI/TIA-569-C - Telecommunications Pathways and Spaces

   d. ANSI/TIA-606-B - Administration Standard for Commercial Telecommunications Infrastructure

e. ANSI/TIA-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

f. ANSI/TIA-758-B - Customer-Owned Outside Plant Telecommunications Standard

g. ANSI/TIA-862-A - Building Automation Systems Cabling Standard

h. ANSI/TIA-942-A - Telecommunications Infrastructure Standard for Data Centers

i. ANSI/TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling

j. NFPA 70 (NEC) - National Electrical Code (Current Edition)

k. UL 444 - Standard for Safety for Communications Cable

B. Refer to individual sections for additional Quality Assurance requirements.

C. Qualifications:

1. Only products of reputable manufacturers as determined by Fermilab will be acceptable.

2. Each Subcontractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the termination of cabling shall be individually certified by the manufacturer.

3. The Subcontractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

4. The Subcontractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and copper structured cabling systems and have personnel adequately trained in the use of such tools and equipment.

D. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Subcontractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Subcontractor shall complete and return a signed “Electronic File Transmittal” form provided by KJWW.

4. If the information requested includes floor plans prepared by others, the Subcontractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by KJWW for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Subcontractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Subcontractor with no guarantee by KJWW as to the accuracy or correctness of the information provided. KJWW accepts no responsibility or liability for the Subcontractor's use of these documents.

E. Field Measurements:

1. Before ordering any materials, this Subcontractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

1.6 SUBMITTALS

A. Refer to Division 1 for submittal requirements.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site so as to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from deleterious conditions.

1.8 INSURANCE

A. This Subcontractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.9 MATERIAL

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required to be used in this contract.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Subcontractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. Fermilab shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured **in writing** from Fermilab not later than ten (10) days prior to the bid opening date. The Subcontractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. Fermilab may reject manufacturer at time of shop drawing submittal. The Subcontractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Subcontractor be unable to secure approval from Fermilab for other unnamed manufacturers as outlined above, this Subcontractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Subcontractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Subcontractor or on the part of other Subcontractors whose work is affected.

PART 2 - PRODUCTS

2.1 REFER TO INDIVIDUAL SECTIONS

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of Fermilab, nor the presence of Fermilab or his or her employees and subconsultants at a construction site, shall relieve the Subcontractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. Fermilab and his or her personnel have no authority to exercise any control over any construction subcontractor or other entity or their employees in connection with their work or any health or safety precautions. The Subcontractor is solely responsible for jobsite safety. Fermilab and Fermilab's consultants shall be indemnified and shall be made additional insureds under the Subcontractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduits shall comply with Sections 16111 and 16120. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 16111. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Subcontractor carry the least stringent condition in the pricing.

B. It is the Subcontractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. The Subcontractor shall be responsible for identifying and reporting to Fermilab any existing conditions including but not limited to damage to walls, flooring, ceiling and furnishings prior to start of work. All damage to interior spaces caused by this Subcontractor shall be repaired at this Subcontractor's expense to pre-existing conditions, including final colors and finishes.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 17 sections for further requirements.

2. The Subcontractor shall conduct all tests required and applicable to the work both during and after construction of the work.

3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Subcontractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.

4. In the event the results obtained in the tests are not satisfactory, This Subcontractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as Fermilab or code enforcing agency deems necessary.

5. All telecommunications tests that fail shall be remedied by the Subcontractor without cost to the project.

B. Protection of cable from foreign materials:

1. It is the Subcontractor's responsibility to provide adequate physical protection to prevent foreign material application. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. Fermilab will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.

2. Refer to the end of this specification section for a “STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION.”

3. The Subcontractor shall sign this form and return it to Fermilab so that the final observation can commence.

C. Before final payment will be authorized, this Subcontractor must have completed the following:

1. Submitted operation and maintenance manuals to Fermilab for review.

2. Submitted bound copies of approved shop drawings.

3. Record documents including edited drawings and specifications accurately reflecting field conditions, **inclusive** of all project revisions, change orders, and modifications.

4. Submitted a report stating the instructions given to Fermilab's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Subcontractor and shall be signed by Fermilab's representative as having received the instructions.

5. Submitted testing reports for all systems requiring final testing as described herein.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Fermilab’s review and approval. The electronic copy shall be corrected as required to address Fermilab’s comments. Once corrected, electronic copies and paper copies shall be distributed as directed by Fermilab.

2. Approved O&M manuals shall be completed and in Fermilab's possession prior to Fermilab's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by Fermilab.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div27.subcontractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div27.subcontractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide Fermilab with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Subcontractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final <u>approved</u> shop drawings and submittals. Include Architect’s/Engineer’s shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copy of final approved test and balance reports.

5. Copies of warranties.

6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

7. Dimensional drawings of equipment.

8. Capacities and utility consumption of equipment.

9. Detailed parts lists with lists of suppliers.

10. Operating procedures for each system.

11. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

12. Repair procedures for major components.

13. List of lubricants in all equipment and recommended frequency of lubrication.

14. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING FERMILAB'S REPRESENTATIVE

A. Adequately instruct Fermilab's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to Fermilab's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

3.7 SYSTEM COMMISSIONING

A. The Communications Systems included in the construction documents are to be complete and operating systems. Fermilab will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Subcontractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Subcontractor, subcontractors, and equipment suppliers are expected to have skilled technicians to insure that the system performs as designed. If Fermilab is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Subcontractor shall reimburse Fermilab on a time and material basis for services rendered at Fermilab's standard hourly rates in effect at the time the services are requested. The Subcontractor shall be responsible for making payment to Fermilab for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Subcontractor shall maintain at the job site, a separate and complete set of Communications Drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Communications Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Subcontractor fail to complete Record Documents as required by this contract, This Subcontractor shall reimburse Fermilab for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at Fermilab’s hourly rates in effect at the time of work.

D. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

E. Upon completion of the job, and before final payment is made, This Subcontractor shall give the marked-up drawings to Fermilab.

3.9 ADJUST AND CLEAN

A. Subcontractor shall thoroughly clean all equipment and systems prior to Fermilab's final acceptance of the project.

B. Subcontractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Subcontractor shall remove all rubbish, debris, etc., accumulated during the Subcontractor's operations from the premises.

END OF SECTION 17010

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

In order to assist the subcontractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The subcontractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to Fermilab, shall indicate the subcontractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, conduit sleeves, etc) are installed and all cabling has been pulled through them.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
3. All telecommunications related grounding is complete.

The project will be ready for final jobsite observation prior to the requested date of the observation, according to the above list of requirement.

Prime Subcontractor: _____ By: _____

Requested Observation Date _____ Today's Date: _____

Subcontractor shall sign this readiness statement and transmit to Fermilab at least 10 days prior to the requested date of observation.
It is understood that if Fermilab finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, Fermilab will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Subcontractor at our standard hourly rates, including travel expenses or the subcontractor's retainage may be deducted for the same amount.

SECTION 17050 - COMMUNICATIONS BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bonding Conductors
B. Bonding Connectors
C. Grounding Busbar (TMGB and TGB)

1.2 RELATED WORK

A. Section 16111 – Conduit
B. Section 16114 – Cable Trays
C. Section 16120 – Wire and Cable
D. Section 16450 – Grounding and Bonding
E. Section 16670 – Lightning Protection Systems
F. Section 17010 – Basic Communications Systems Requirements
G. Section 17080 – Through Penetration Firestopping
H. Section 17110 – Communication Equipment Rooms

1.3 QUALITY ASSURANCE

A. Refer to Section 17010 for relevant standards.

B. Communications bonding system component, device, equipment, and material manufacturer(s) shall have a minimum of five (5) years documented experience in the manufacture of communications bonding products.

C. The entire installation shall comply with all applicable electrical codes, safety codes, and standards. All applicable components, devices, equipment, and material shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ANSI/IEEE 1100 – Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems

B. ANSI/TIA/EIA 568-C – Commercial Building Telecommunications Cabling Standard

C. ANSI/TIA/EIA 569-A – Commercial Building Standard for Telecommunications Pathways and Spaces

D. ANSI/TIA/EIA 606 – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

E. ANSI/TIA/EIA 758 – Customer Owned Outside Plant

F. ANSI-J-STD-607-A – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

G. IEEE 81 – IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

H. IEEE 837 – IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

I. NFPA 70 – National Electrical Code

J. NFPA 780 – Standard for the Installation of Lightning Protection Systems

K. UL 96 – Lightning Protection Components

L. UL 96A – Installation Requirements for Lightning Protection Systems

M. UL 467 – Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 17010 and Division 1.

B. Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item, including construction, materials, ratings, and all other parameters identified in Part 2 - Products.

2. Manufacturer's installation instructions indicating application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Provide CAD-generated, project-specific system shop drawings as follows:

1. Provide a system block diagram indicating system configuration, system components, interconnection between components, and conductor routing. The diagram shall clearly indicate all wiring and connections required in the system. When multiple devices or pieces of equipment are required in the exact same configuration (e.g., multiple identical equipment racks or sections of ladder tray), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where system equipment will be located.

2. Installation details for all system components.

D. Provide system checkout test procedure to be performed at acceptance.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 17010.

B. Store and protect products under the provisions of Section 17010.

C. Subcontractor shall exercise care to prevent corrosion of any products prior to installation. Corroded products shall not be acceptable for use on this project.

1.7 SYSTEM DESCRIPTION

A. This section describes the requirements for the furnishing, installation, adjusting, and testing of a complete turnkey communications bonding system, including connection to the electrical ground grid.

B. Performance Statement: This specification section and the accompanying drawings are performance based, describing the minimum material quality, required features, operational requirements, and performance of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made, or every feature and function that must be configured. Based on the equipment constraints described and the performance required of the system as presented in these documents, the Subcontractor is solely responsible for determining all components, devices, equipment, wiring, connections, and terminations required for a complete and operational system that provides the required performance.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment, and other miscellaneous equipment required for complete, proper system installation and operation shall be provided by the Subcontractor.

D. Basic System Requirements:

1. A complete communications bonding infrastructure is required for this project. Refer to the drawings and the requirements of ANSI-J-STD-607-A and NFPA 70 for complete information.

2. The bonding system shall include, but not be limited to, the following major components:

a. Bonding Conductor for Telecommunications (BCT)
b. Telecommunications Main Grounding Busbar (TMGB)
c. Telecommunications Bonding Backbone (TBB)
d. Telecommunications Grounding Busbar(s) (TGB)
e. Bonding Conductor(s) (BC)
f. Bonding Connectors
g. Bonding system labeling.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 17010.

B. Provide final system block diagram showing any deviations from approved shop drawing submittal.

C. Provide floor plans that document the following:

1. Actual locations of system components, devices, and equipment.
2. Actual conductor routing.
3. Actual system component, device, equipment, and conductor labels.

D. Provide statement that system checkout test, as outlined in the approved shop drawing submittal, is complete and test results were satisfactory.

E. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 17010.

B. Submitted data shall include:

1. Approved shop drawings.

2. Descriptions of recommended system maintenance procedures, including:

a. Inspection
b. Periodic preventive maintenance
c. Fault diagnosis
d. Repair or replacement of defective components

PART 2 - PRODUCTS

2.1 BONDING CONDUCTORS

A. Bare Copper:

1. Annealed uncoated stranded conductor.
2. Minimum size 6 AWG.

B. Insulated Copper:

1. Annealed uncoated stranded conductor.

2. Insulation:

a. PVC insulation with nylon outer jacket.
b. Rated ≥ 600 volts.
c. Green.

3. Minimum size 6 AWG.

C. All bonding conductors shall be listed and recognized by a nationally recognized testing laboratory as being suitable for the intended purpose and for installation in the space in which they are installed.

D. Bonding Conductor Sizing

1. All Communications bonding system conductors shall be sized by length as follows:

Length Linear ft (m)	Size (AWG)
Less than 13 (4)	6
14 - 20 (4 - 6)	4
21 - 26 (6 - 8)	3
27 - 33 (8 - 10)	2
34 - 41 (10 - 13)	1
42 - 52 (13 - 16)	1/0
53 - 66 (16 - 20)	2/0
Greater than 66 (20)	3/0

2. The BCT shall be the same size as the TBB or larger.

2.2 BONDING CONNECTORS

A. Acceptable Types:

1. Two-hole compression lug
2. Exothermic weld
3. Irreversible compression

B. Connectors shall be provided in kit form and selected per manufacturer's written instructions.

C. Connectors shall comply with IEEE 837 and UL 467 and be listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING BUSBAR (TMGB AND TGB)

A. Features:

1. Wall-mount configuration.
2. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
3. Hole patterns compliant with BICSI recommendations and ANSI-J-STD-607-A standards.
4. Predrilled holes.
5. Integral insulators.
6. Stainless steel offset mounting brackets.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.

2. Minimum Dimensions: 1/4" thick x 4" high x 12" long.

   a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

   a. A minimum of 15 sets of 5/16” holes, 5/8” on center, to accommodate “A” spaced 2-hole compression lugs.

   b. A minimum of three (3) sets of 7/16” holes, 1” on center, to accommodate “C” spaced 2-hole compression lugs.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Bonding Requirements:

1. The communications bonding system shall be a complete system. Subcontractor shall furnish and install all necessary miscellaneous components, devices, equipment, material, and hardware, including, but not limited to, lock washers, paint-piercing washers, hex nuts, compression lugs, insulators, mounting screws, lugs, etc., to provide a complete system.

2. A licensed electrician shall perform all bonding.

3. Comply with the manufacturer’s instructions and recommendations for installation of all products.

B. Main Cross Connect and Service Entrance Room Bonding Requirements:

1. Locate the TMGB in the service entrance room unless otherwise noted on the drawings.

2. The location of the TMGB shall be the shortest practical distance from the telecommunications primary lightning protection devices.

3. Bond the telecommunications primary protectors to the TMGB. Maintain a minimum 1 foot (300 mm) separation of the bonding conductor from all DC power cables, switchboard cable, and high frequency cable.

4. In service entrance rooms where the entrance pathway contains an isolation gap, the pathway on the facility side of the gap shall be bonded to the TMGB.

C. Telecommunications Main Ground Bar (TMGB) Requirements:

1. Install TMGB such that it is insulated from its support with a minimum 2” standoff.

2. Bond the TMGB to the electrical service ground via the BCT.

   a. A minimum of 1 foot (300 mm) separation shall be maintained between the BCT and any DC power cables, switchboard cable, or high frequency cables.

3. TMGB shall be bonded to all electrical panels located in the same room or space as the TMGB or in an immediately adjacent space within 20 linear feet of the TMGB. TMGB shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TMGB.

4. TMGB shall be bonded to accessible metallic building structure located within the same room or space as the TMGB.

5. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TMGB, shall be bonded to the TMGB.

D. Telecommunications Ground Bar (TGB) Requirements:

1. Provide a TGB in the telecommunications equipment room.

2. Install TGB such that it is insulated from its support with a minimum 2” standoff.

3. Bond each TGB to the TMGB via the TBB.

a. A minimum of 1 foot (300 mm) separation shall be maintained between the TBB and any DC power cables, switchboard cable, or high frequency cables.

b. The TBB may be routed from TGB to TGB or as a radial feed to each TGB as the layout requires.

4. TGBs shall be bonded to accessible metallic building structure located within the same room or space as the TGBs.

5. TGBs shall be bonded to all electrical panels located in the same room or space as the TGB or in an immediately adjacent space within 20 linear feet of the TGB. TGBs shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TGB.

6. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TGB, shall be bonded to the TGB.

E. Metallic Interior Communication Pathway Bonding Requirements:

1. All metallic interior continuous communication cable pathways, including, but not limited to, conduit, conduit sleeves, fire-rated cable pathway devices, cable tray, basket tray, and ladder rack, shall be bonded to the communications bonding system.

F. Bonding Conductor Requirements:

1. Bonding conductors shall be green or marked with a distinctive green color.

2. Bonding conductors shall be routed parallel and perpendicular to building structure along shortest and straightest paths possible. Number of bends and changes in direction should be minimized. Install and secure conductors in a manner that protects the conductors from impact and from physical or mechanical strain or damage.

3. Bonding conductors shall not be installed in metallic conduit.

4. All conductors, including, but not limited, to the BCT, TBB, GE(s), and BC(s), shall be installed splice-free. If the Subcontractor believes that site conditions do not allow a splice-free installation, the Subcontractor may request permission from Fermilab to splice a specific communications bonding system conductor.

   a. Where documented permission to splice a conductor is granted:

      1) The number of splices shall be limited to as few as possible.

      2) Splices shall be made using exothermic welding or irreversible compression-type connections only. Splice hardware shall be listed for grounding and bonding. Solder is not an acceptable means of splicing conductors.

      3) Splices shall be made in telecommunications spaces in accessible locations to facilitate future inspection and maintenance.

      4) Splices shall be adequately supported and protected from impact and from physical or mechanical strain or damage.

5. All bonding conductors shall be labeled.

   a. Labels shall be nonmetallic.

   b. Labels shall be printer-generated.

   c. Labels shall be located on conductors as close as is practical to their point of termination in a readable position.

   d. Additionally, conductors shall be labeled as follows:

      1) “IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.”

6. Interior water piping is not acceptable for use as a communications bonding system bonding conductor.

7. Metallic cable shields are not acceptable for use as communications bonding system bonding conductors.

G. Bonding Connection Requirements:

1. Make all connections in accessible locations to facilitate future inspection and maintenance.

2. Communications bonding system connections shall be made using exothermic welding, two-hole compression lugs, or other irreversible compression-type connections. The use of 1-hole lugs is prohibited, except for connections to a rack-mount telecommunications ground bar. Connection hardware shall be listed for grounding and bonding. Sheet metal screws shall not be used to make communications bonding system connections.

3. Thoroughly clean conductors before installing lugs and connectors.

4. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tool(s) recommended by the manufacturer for that purpose. Exercise care not to tighten connectors beyond manufacturer's recommendations.

5. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond at all connections.

6. All bonding connections shall be coated in anti-oxidant joint compound that is purpose-designed and purpose-manufactured for that use. Anti-oxidant joint compound shall be applied in accordance with manufacturer's recommendations and instructions.

7. All installed connectors on conductors installed in damp locations shall be sealed with dielectric grease and then covered with heat shrink tubing to protect against moisture ingress. Applied heat shrink tubing shall overlap conductor's outer jacket a minimum of four (4) inches past connector and be installed in accordance with manufacturer's recommendations and instructions.

3.2 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed under provisions of Section 17010.

B. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product from a reputable manufacturer that meets the requirements of the specifications.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Subcontractor of responsibility for compliance with the contract documents.

3.3 ADJUSTING

A. Adjust work under provisions of Section 17010.

B. Subcontractor shall make any and all adjustments to the communications bonding system necessary to ensure that the installed system meets all requirements listed herein. Modifications necessary to comply with listed requirements or to provide specified performance shall be completed by the Subcontractor at no additional cost to Fermilab.

3.4 TESTING

A. Measure and document resistance to ground at TMGB, each TGB, each RTGB, and each electrical distribution panel bonded to the TMGB or a TGB.

1. Measurements shall be made not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.

2. Measured resistance to ground at TMGB, each TGB, and each RTGB must not exceed 5 ohms.

3. <u>Under no circumstances shall any point in the communications bonding system have a lower resistance to ground than that of nearby electrical distribution system components that it is bonded to.</u>

B. Include measurement documentation in test data submitted at completion of project.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two week's advanced notice of training to Fermilab and Fermilab.

2. Fermilab shall be presented with the option to attend the training.

3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. A course detailing the system functions and operations that a technical user will encounter. Provide training on all aspects of using the system, including making new bonding connections to the TMGB, TGB, or RTGB. Provide training on all recommended inspection, maintenance, and repair procedures for the system.

C. Minimum on-site training times shall be:

1. Technical user: One hour.

END OF SECTION 17050

SECTION 17110 - COMMUNICATION EQUIPMENT ROOMS (CER)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for Communication Equipment Rooms. Communication Equipment Rooms include rooms for the Main Cross Connect (MC), Intermediate Cross Connect (IC), Horizontal Cross Connect (HC), Service Entrance Room (SER) and Equipment Room (ER) (such as data centers and main computer rooms housing servers, mainframes and other central equipment).

B. Definitions:

1. Main Cross Connect (MC): Allows single point administration of technology components for cross-connect of first level backbone cables, entrance cables and equipment cables.

2. Intermediate Cross Connect (IC): Cross connect location between a backbone cable extending from the main cross connect (first level backbone) and the backbone cable from the horizontal cross connect (second level backbone).

3. Horizontal Cross Connect (HC): Cross connect location between the horizontal cabling and the backbone cabling.

4. Service Entrance Room: Accommodates a single location for incoming services to terminate and indicates an interface point and division of responsibility between the building cabling system and the service provider (herein referred to as the demarc).

C. Refer to Specification Section 17130 for cable pathway and support requirements.

1.2 RELATED WORK

A. Section 17010 - Basic Communications Systems Requirements
B. Section 17050 - Communications Bonding

1.3 QUALITY ASSURANCE

A. Refer to Section 17010 for applicable standards.

1.4 SUBMITTALS

A. Under the provisions of Section 17010 and Division 1, prior to the start of work the Subcontractor shall submit:

1. Manufacturer's data covering <u>all</u> products including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include ladder racking, equipment racks, cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 17010 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDING

A. Refer to specification section 17050 for grounding requirements.

B. All equipment required to be grounded shall be provided with a grounding lug suitable for termination of the specified size electrode conductor.

2.2 LADDER RACK

A. Provide complete ladder rack system including ladder rack, splice connectors, fastening hardware and other miscellaneous materials as required for a complete installation per manufacturer's recommendations.

B. Fiberglass Stringer Style Ladder Rack.

2.3 DEMARCATION REQUIREMENTS

A. Subcontractor shall coordinate all requirements for the demarcation point with Fermilab's selected service provider.

B. The Subcontractor shall not proceed with any installation without written communication with Fermilab should the service provider's requirements differ from the work shown on the contract documents.

C. Refer to the drawings for further requirements.

PART 3 - EXECUTION

3.1 LADDER RACK

A. Provide support for ladder rack on 4 ft centers.

B. Maintain a 1.5 safety factor on all load limits specified herein.

C. Ladder rack support shall be by 5/8" diameter fiber glass threaded rod when ceiling mounted. Ladder rack requiring wall mounting shall utilize accessories supplied by the ladder rack manufacturer specifically for the purpose of wall mounting ladder rack.

3.2 GROUNDING

A. Provide a complete grounding system in accordance with the requirements of Section 17050.

3.3 CONDUITS AND CABLE ROUTING

A. Refer to Section 16111 for additional requirements.

B. Where conduits enter a telecommunications room, conduits shall be terminated on the wall where shown on the contract documents.

C. All conduits shall be reamed and shall be installed with a nylon bushing.

D. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2” or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2”, maintain a bend radius of at least 10 times the internal diameter.

END OF SECTION 17110