

State of North Carolina 216
Department of Transportation
Raleigh

ELIZABETH CITY BRIDGE OVER PASQUOTANK RIVER

SPECIAL PROVISIONS



Project No. U-4438
Pasquotank County
Station 15+25.75 -L1-



PROJECT U-4438

PASQUOTANK COUNTY

**Project Special Provisions
Bascule Structure**

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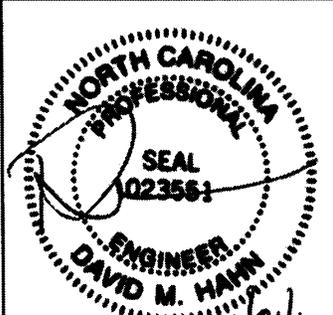
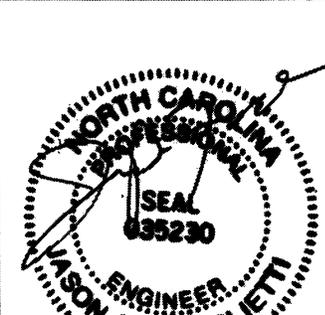
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PROFESSIONAL REGISTRATIONS AND RESPONSIBILITIES

 <p>Project Special Provisions Bascule-Specific Special Provisions</p>	 <p><u>Appendix A</u> Section 051200 Section 053100 Section 054000 Section 054500</p>	 <p><u>Appendix A</u> Section 055213 Section 061600 Section 074113 Section 074110 Section 074120 Section 076200 Section 084113 Section 092900 Section 093100 Section 095123 Section 096623 Section 099120 Section 099123</p>
 <p><u>Appendix A</u> Mechanical</p>	 <p><u>Appendix A</u> Electrical</p>	

SAND LIGHTWEIGHT CONCRETE

(SPECIAL)

Use sand lightweight concrete, as noted on the plans, that meets the requirements of this Special Provision.

Sand lightweight concrete is composed of portland cement, fine aggregate, lightweight coarse aggregate, water, and admixtures. Provide sand lightweight concrete that complies with the applicable requirements of Sections 420, 1000, and 1024 of the Standard Specifications and the additional requirements herein.

Submit a mix design from a testing laboratory approved by the NC Division of Highways for approval at least 35 days prior to the proposed use. Provide a mix meeting Table 1000-1 of the Standard Specifications and the following design criteria:

TEST	TEST METHOD	REQUIREMENT
Max. Unit Weight, plastic, lbs/ft ³ (kg/m ³)	AASHTO T121	120 (1925)
Max. Unit Weight, dry, lbs/ft ³ (kg/m ³)	ASTM C567 using equilibrium air dried unit weight	115 (1845)
Min. Relative Dynamic Modulus, (percent)	AASHTO T161 Procedure A	80

When submitting the mix design, include the source of the aggregates, cement, and admixtures and the gradation, specific gravity and fineness modulus (fine aggregate only) of the aggregates. Submit test results showing the mix design conforms to the criteria, including the 28 day compressive strength of a minimum of six cylinders. Provide a mix design that produces an average compressive strength sufficient to ensure that a minimum strength of 4500 psi (31.0 MPa) is achieved in the field.

Produce an additional mix in accordance with AASHTO M195 to determine the drying shrinkage. The maximum drying shrinkage for this mix is 0.07%.

For lightweight aggregate, use expanded shale or slate that meets the requirements of AASHTO M195. Grade the lightweight aggregate in accordance with 1014-2(E)(6).

Determine the soundness in accordance with AASHTO T104. Loss of more than 10% of the lightweight aggregate in five cycles of the accelerated soundness test using sodium sulfate is not permitted.

Ensure the lightweight aggregate is in a saturated surface-dry condition when it is proportioned and incorporated into the mix.

Verify the unit weight of the sand lightweight concrete by two test blocks made during the placement of the concrete for the bridge railing and two test blocks made during the placement of the concrete for the partially-filled steel grid deck. Each test block shall have a volume of one cubic foot. Weigh each block promptly after casting and again 28 days later. Provide the weights of these blocks to the Engineer for review and approval.

SUBMITTAL OF WORKING DRAWINGS

(SPECIAL)

1.0 GENERAL

Submit working drawings in accordance with Article 105-2 of the *Standard Specifications* and this provision. For this provision, "submittals" refers to only those listed in this provision, unless noted otherwise. The list of submittals contained herein does not represent a list of required submittals for the project. Submittals are only necessary for those items as required by the contract. Make submittals that are not specifically noted in this provision directly to the Resident Engineer. Either the Structure Design Unit or the Geotechnical Engineering Unit or both units will jointly review submittals.

If a submittal contains variations from plan details or specifications or significantly affects project cost, field construction or operations, discuss the submittal with and submit all copies to the Resident Engineer. State the reason for the proposed variation in the submittal. To minimize review time, make sure all submittals are complete when initially submitted. Provide a contact name and information with each submittal. Direct any questions regarding submittal requirements to the Resident Engineer, Structure Design Unit contacts or the Geotechnical Engineering Unit contacts noted below.

In order to facilitate in-plant inspection by NCDOT and approval of working drawings, provide the name, address and telephone number of the facility where fabrication will actually be done if different than shown on the title block of the submitted working drawings. This includes, but is not limited to, precast concrete items, prestressed concrete items and fabricated steel or aluminum items.

2.0 SCHEDULING

The following scheduling requirements apply to all submittals for the Project. Submittals will be reviewed and returned with the following additional considerations:

1. Except as noted below, submittals will be reviewed and returned within 40 calendar days.
2. A maximum of 40 shop drawings can be expected to be reviewed and returned per week (five working days). Catalog cuts are considered within this limitation of 40 drawings with three catalog cuts equated to one shop drawing. Means and Methods drawings are counted as shop drawings. When more than 40 drawings are submitted per week for review, coordinate a reasonable return date with the Engineer.

3. Include sufficient time in the schedule for revisions and subsequent reviews of submittals that are not approved.

3.0 ADDRESSES AND CONTACTS

For submittals to the Structure Design Unit, use the following addresses:

Via US mail:

Mr. G. R. Perfetti, P. E.
State Bridge Design Engineer
North Carolina Department
of Transportation
Structure Design Unit
1581 Mail Service Center
Raleigh, NC 27699-1581

Attention: Mr. P. D. Lambert, P. E.

Via other delivery service:

Mr. G. R. Perfetti, P. E.
State Bridge Design Engineer
North Carolina Department
of Transportation
Structure Design Unit
1000 Birch Ridge Drive
Raleigh, NC 27610

Attention: Mr. P. D. Lambert, P. E.

Submittals may also be made via email.

Send submittals to:

plambert@ncdot.gov (Paul Lambert)

Send an additional e-copy of the submittal to the following address:

jgaither@ncdot.gov (James Gaither)

For submittals to the Geotechnical Engineering Unit, use the following addresses:

For projects in Divisions 1-7, use the following Eastern Regional Office address:

Via US mail:

Mr. K. J. Kim, Ph. D., P. E.
Eastern Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Eastern Regional Office
1570 Mail Service Center
Raleigh, NC 27699-1570

Via other delivery service:

Mr. K. J. Kim, Ph. D., P. E.
Eastern Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Eastern Regional Office
3301 Jones Sausage Road, Suite 100
Garner, NC 27529

For projects in Divisions 8-14, use the following Western Regional Office address:

Via US mail:

Mr. John Pilipchuk, L. G., P. E.
Western Regional Geotechnical
Manager
North Carolina Department
of Transportation

Via other delivery service:

Mr. John Pilipchuk, L. G., P. E.
Western Region Geotechnical
Manager
North Carolina Department
of Transportation

Geotechnical Engineering Unit
Western Regional Office
5253 Z Max Boulevard
Harrisburg, NC 28075

Geotechnical Engineering Unit
Western Regional Office
5253 Z Max Boulevard
Harrisburg, NC 28075

The status of the review of structure-related submittals sent to the Structure Design Unit can be viewed from the Unit's web site, via the "Contractor Submittal" link.

Direct any questions concerning submittal review status, review comments or drawing markups to the following contacts:

Primary Structures Contact:

Paul Lambert
(919) 250 – 4041
(919) 250 – 4082 facsimile
plambert@ncdot.gov

Secondary Structures Contacts:

James Gaither (919) 250 – 4042
David Stark (919) 250 – 4044

Eastern Regional Geotechnical Contact (Divisions 1-7):

K. J. Kim
(919) 662 – 4710
(919) 662 – 3095 facsimile
kkim@ncdot.gov

Western Regional Geotechnical Contact (Divisions 8-14):

John Pilipchuk
(704) 455 – 8902
(704) 455 – 8912 facsimile
jpilipchuk@ncdot.gov

4.0 SUBMITTAL COPIES

Furnish one complete copy of each submittal, including all attachments, to the Resident Engineer. At the same time, submit the number of hard copies shown below of the same complete submittal directly to the Structure Design Unit and/or the Geotechnical Engineering Unit.

The first table below covers "Structure Submittals". The Resident Engineer will receive review comments and drawing markups for these submittals from the Structure Design Unit. The second table in this section covers "Geotechnical Submittals". The Resident Engineer will receive review comments and drawing markups for these submittals from the Geotechnical Engineering Unit.

Unless otherwise required, submit one set of supporting calculations to either the Structure Design Unit or the Geotechnical Engineering Unit unless both units require submittal copies in which case submit a set of supporting calculations to each unit. Provide additional copies of any submittal as directed by the Engineer.

STRUCTURE SUBMITTALS

Submittal	Copies Required by Structure Design Unit	Copies Required by Geotechnical Engineering Unit	Contract Reference Requiring Submittal ¹
Arch Culvert Falsework	5	0	Plan Note, SN Sheet & "Falsework and Formwork"
Box Culvert Falsework ⁷	5	0	Plan Note, SN Sheet & "Falsework and Formwork"
Cofferdams	6	2	Article 410-4
Evazote Joint Seals ⁶	9	0	"Evazote Joint Seals"
Expansion Joint Seals (hold down plate type with base angle)	9	0	"Expansion Joint Seals"
Expansion Joint Seals (modular)	2, then 9	0	"Modular Expansion Joint Seals"
Expansion Joint Seals (strip seals)	9	0	"Strip Seals"
Falsework & Forms ² (substructure)	8	0	Article 420-3 & "Falsework and Formwork"
Falsework & Forms (superstructure)	8	0	Article 420-3 & "Falsework and Formwork"
Girder Erection over Railroad	5	0	Railroad Provisions
Maintenance and Protection of Traffic Beneath Proposed Structure	8	0	"Maintenance and Protection of Traffic Beneath Proposed Structure at Station ____"
Metal Bridge Railing	8	0	Plan Note
Metal Stay-in-Place Forms	8	0	Article 420-3
Metalwork for Elastomeric Bearings ^{4,5}	7	0	Article 1072-10
Miscellaneous Metalwork ^{4,5}	7	0	Article 1072-10
Optional Disc Bearings ⁴	8	0	"Optional Disc Bearings"
Overhead Signs	13	0	Article 903-3(C) &

			Applicable Provisions
Pile Splicers	7	2	Subarticle 450-7(C) & "Piles"
Pile Points	7	2	Subarticle 450-7(D) & "Piles"
Placement of Equipment on Structures (cranes, etc.)	7	0	Article 420-20
Pot Bearings ⁴	8	0	"Pot Bearings"
Precast Concrete Box Culverts	2, then 1 reproducible	0	"Optional Precast Reinforced Concrete Box Culvert at Station ____"
Precast Retaining Wall Panels	10	1	Article 1077-2
Prestressed Concrete Cored Slab (detensioning sequences) ³	6	0	Article 1078-11
Prestressed Concrete Deck Panels	6 and 1 reproducible	0	Article 420-3
Prestressed Concrete Girder (strand elongation and detensioning sequences)	6	0	Articles 1078-8 and 1078-11
Removal of Existing Structure over Railroad	5	0	Railroad Provisions
Revised Bridge Deck Plans (adaptation to prestressed deck panels)	2, then 1 reproducible	0	Article 420-3
Revised Bridge Deck Plans (adaptation to modular expansion joint seals)	2, then 1 reproducible	0	"Modular Expansion Joint Seals"
Sound Barrier Wall Casting Plans	10	0	Article 1077-2 & "Sound Barrier Wall"
Sound Barrier Wall Steel Fabrication Plans ⁵	7	0	Article 1072-10 & "Sound Barrier Wall"
Structural Steel ⁴	2, then 7	0	Article 1072-10

Temporary Detour Structures	10	2	Article 400-3 & "Construction, Maintenance and Removal of Temporary Structure at Station ____"
TFE Expansion Bearings ⁴	8	0	Article 1072-10

FOOTNOTES

1. References are provided to help locate the part of the contract where the submittals are required. References in quotes refer to the provision by that name. Articles and subarticles refer to the *Standard Specifications*.
2. Submittals for these items are necessary only when required by a note on plans.
3. Submittals for these items may not be required. A list of pre-approved sequences is available from the producer or the Materials & Tests Unit.
4. The fabricator may submit these items directly to the Structure Design Unit.
5. The two sets of preliminary submittals required by Article 1072-10 of the *Standard Specifications* are not required for these items.
6. Submittals for Fabrication Drawings are not required. Submittals for Catalogue Cuts of Proposed Material are required. See Section 5.A of the referenced provision.
7. Submittals are necessary only when the top slab thickness is 18" or greater.

GEOTECHNICAL SUBMITTALS

Submittal ¹	Copies Required by Geotechnical Engineering Unit	Copies Required by Structure Design Unit	Contract Reference Requiring Submittal ²
Crosshole Sonic Logging (CSL) Reports	1	0	"Crosshole Sonic Logging"
Drilled Pier Construction Sequence Plans	1	0	"Drilled Piers"
Pile Driving Analyzer (PDA) Reports	2	0	"Pile Driving Analyzer"
Pile Driving Equipment Data ³	1	0	Article 450-5 & "Piles"

Retaining Walls	8	2	Applicable Provisions “Temporary Shoring”, “Anchored Temporary Shoring” & “Temporary Soil Nail Walls”
Contractor Designed Shoring	7	2	

FOOTNOTES

1. With the exception of “Pile Driving Equipment Data”, electronic copies of geotechnical submittals are required. See referenced provision.
2. References are provided to help locate the part of the contract where the submittals are required. References in quotes refer to the provision by that name. Articles refer to the *Standard Specifications*.
3. Download Pile Driving Equipment Data Form from following link:
<http://www.ncdot.org/doh/preconstruct/highway/geotech/formdet/>
Submit one hard copy of the completed form to the Resident Engineer. Submit a second copy of the completed form electronically, by facsimile or via US Mail or other delivery service to the Geotechnical Engineering Unit. Electronic submission is preferred. See second page of form for submittal instructions.

PROJECT U-4438

PASQUOTANK COUNTY

BASCULE-SPECIFIC SPECIAL PROVISIONS

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BASCULE-SPECIFIC SPECIAL PROVISIONS
STRUCTURE

PROJECT U-4438

PASQUOTANK COUNTY

CONTRACTOR EXPERIENCE

Provide documentation demonstrating prior experience of the bascule contractor or their assigned superintendent in the construction of bascule bridges. Submit project name(s), details, contact name(s), contact phone number(s), and relevant résumés for at least one bascule bridge construction project within the past ten years.

CONTRACTOR OPERATION OF THE BRIDGES

1.0 GENERAL

Assume responsibility for operating the existing bridge(s) and the new bridge from the time that the normal operating procedure is affected by construction activities until the new control system is in place, complete and fully operable in its final form from the new eastbound bridge control house, all westbound bridge preservation work is complete, and all required training is complete and the final approved editions of all required manuals are delivered. The contractor will also assume responsibility for routine greasing and operational maintenance of the bascule mechanical equipment during this time. NCDOT will maintain responsibility for other mechanical and electrical maintenance and any repairs not the fault of the contractor.

Factors that are considered as affecting the normal operating procedure include: work on the bridge machinery, work on the bridge electrical control system, work that affects the traffic gates, any work that affects span balance, contractor staff, materials and/or equipment on or in the bascule piers or interfering with the bridge operator's view of roadway or waterway traffic.

During this period of Contractor-supervised operation, provide at least one operator at the bridge at all times (24 hours a day, seven days a week) as required by the United States Coast Guard regulations for this specific bridge location. The Contractor is required to provide a sufficient number of qualified personnel to accomplish this work and still accommodate employee leave and absenteeism: The Department will provide on the job training to the Contractor and Bridge Operators for a maximum of twenty (20) week days on a schedule approved by the Engineer. Training may take place on any shift. All costs associated with this training shall be the responsibility of the Contractor.

Training of successive bridge operators will be the responsibility of the Contractor. The Contractor shall insure that all bridge operators are trained in the performance of their duties and are certified by the Bridge Maintenance Supervisor.

Requirements for certification of a bridge operator are as follows:

- A. Complete reading of the Bridge Operators Manual.
- B. Demonstrate ability to operate the bridge and express knowledge of the operation to the Bridge Maintenance Supervisor.
- C. Complete 4 hours of instruction by Bridge Maintenance Electricians.
- D. Complete 80 hours of instruction by other operators or the Supervisor, to include a minimum of 10 openings per shift.
- E. Complete check-off on normal and emergency procedures.
- F. Complete 16 hours of General Safety Training as listed in Bridge Operator's Manual Part 1, Page 2(a). N.C. Department of Transportation will provide initial training. Any additional training will be the responsibility of the Contractor.

Provide any adjustments or corrections required during this period of Contractor-supervised operation at no additional cost.

2.0 CONTRACTOR-SUPERVISED BRIDGE OPERATION

In addition to the formal training sessions required elsewhere by these Special Provisions, provide a minimum of two men to supervise the operation of the bridge for a period of 14 consecutive calendar days (24 hours a day) after the Department has taken over operation of the lift span; and for an additional 14-day period (24 hours a day), provide one man.

These men shall be able to operate the bridge, to supervise its operation, and to make any adjustments or corrections that may be required in the mechanical or electrical equipment of the bridge. They shall also further instruct and qualify the employees of the Department in the operation of the bridge. Provide any adjustments or corrections required during the two 14-day periods at no additional cost.

3.0 MAINTENANCE AND ADJUSTMENTS

Maintain, and provide any required adjustments and/or corrections to, all work during construction, and until all required training and the periods of Contractor-supervised lift span operation are complete.

4.0 MEASUREMENT AND PAYMENT

Compliance with the requirements of this Special Provision is considered incidental to the overall project; no measurement or direct payment will be made for any materials, labor, or incidental costs related to compliance with these requirements. Compliance with the requirements of this Special Provision is not considered to be a basis for partial payment against any item.

REMOVAL OF EXISTING BASCULE STRUCTURE AT STA. 15+25.75 -L1-

Remove the existing bascule structure as shown in the plans, including all existing tremie concrete and piles. Also remove the existing fender system in two phases as described in the Suggested Construction Sequence in the plans. Total costs associated with cofferdams are included with this pay item. Provide protection of the existing and new structures against ship collision at all times during construction. Upon removal, the wedges may be salvaged at the direction of Mr. Randy Williams (252)-340-1173. If salvaged, the wedges shall be stored on site and three (3) days notice given to Mr. Williams for him to pick up.

Perform this work in accordance with *2006 Standard Specifications* Section 402 – Removal of Existing Structures and as modified herein.

Revise the *2006 Standard Specifications* as follows:

Page 4-4, Article 402-3 Measurement and Payment, add the following to the list of pay items:

Pay Item	Pay Unit
Removal of Existing Bascule Structure at Sta. 15+25.75 -L1-	Lump Sum

REMOVAL OF PORTION OF EXISTING BASCULE STRUCTURE AT STA. 15+25.75 -L2-

Remove the existing Control House at Pier 1 as shown in the plans, in accordance with the *2006 Standard Specifications* Section 402 – Removal of Existing Structures, and as modified herein. Upon removal, the generator unit shall be salvaged from the Control House and remain the property of the North Carolina Department of Transportation. The generator unit shall be removed carefully and without damage. It shall be stored on site and protected from rain. When

the unit is ready to be picked-up by the Department, give three (3) days notice to Mr. Randy Williams (252)-340-1173.

Revise the 2006 Standard Specifications as follows:

Page 4-2, Article 402-2 Removal of Existing Structure, Subarticle 402-2(A) General, add the following at the end of the first paragraph: There may be asbestos-containing materials in the existing Control House. Comply with all Federal, State, and local asbestos regulations. Asbestos abatement for the removal of the existing Control House will be performed by the Department. Coordinate with the Engineer to schedule this work upon transfer of operational control to the proposed Control House. Make the site available and cooperate with the Asbestos Abatement Contractor. Upon completion of abatement by the Department, continue with removal per the plans. Make no claim for delay due to the Department's performance of Asbestos Abatement.

Page 4-3, Article 402-3, Measurement and Payment, add the following at the end of the first paragraph:

Asbestos abatement will be performed by the Department and is not included with this item.

Page 4-4, Article 402-3 Measurement and Payment, add the following to the list of pay items:

Pay Item	Pay Unit
Removal of Portion of Existing Bascule Structure at Sta. 15+25.75 -L2-	Lump Sum

CONCRETE STRUCTURES

Revise the 2006 Standard Specifications as follows:

Page 4-16, Article 420-2 Materials, add the following to the list of materials:

Item	Section
Sand Lightweight Concrete	See Special Provision for Sand Lightweight Concrete

Page 4-23, Article 420-3 Falsework and Forms, add the following as a new item after 420-3(E)(3):

(F) Sidewalk Void Filler

Provide styrofoam void filler as detailed in the plans. Use styrofoam conforming to Type V of ASTM C578 or approved equal.

Adhere styrofoam to the form pan using adhesive. Use adhesive that is compatible with the styrofoam material so as not to cause the styrofoam to decompose.

Do not use duct tape to hold the styrofoam in place.

Replace styrofoam that is damaged during placement of the reinforcing steel.

Page 10-51, Article 1014-2 Coarse Aggregate, Subarticle (E)(1) General, add the following as the second sentence:

Use No. 78M coarse aggregate in portland cement concrete around the trunnion columns.

Page 4-42, Article 420-21 Measurement and Payment, add the following at the end of the fourth paragraph:

The studded weldment located at the joint between the fixed span and the bascule span is not included with this item.

Page 4-43, Article 420-21 Measurement and Payment, add the following after the first paragraph:

All concrete within the Control House will be included with this item.

Page 4-43, Article 420-21 Measurement and Payment, add the following to the list of pay items:

Pay Item	Pay Unit
Class AA Concrete	Cubic Yard
Sand Lightweight Concrete	Cubic Yard
Class S Concrete (Seal)	Cubic Yard

STEEL STRUCTURES

Revise the *2006 Standard Specifications* as follows:

Page 4-53, Article 440-1 Description, add the following as the fourth paragraph:

Furnish, fabricate, and erect structural steel for the movable bascule span.

Page 4-61, Article 440-10 Measurement and Payment, add the following after the fifth paragraph:

Separate payment will not be made for furnishing, fabricating, and erecting structural steel for the movable bascule span. All costs will be included in the bid price for the pay item "Structural Steel," unless noted otherwise herein.

Page 10-118, Article 1072-4 Shapes, Plates, Bars, and Sheets, replace the first sentence with the following:

Use shapes, plates, bars, and sheets meeting the requirements of AASHTO M270 Grade 50 unless otherwise required by the contract.

Page 10-119, Article 1072-6 Anchor Bolts, replace the second paragraph with the following:

Provide anchor bolts for bearing plate assemblies meeting the requirements of ASTM A449 unless otherwise stated herein or in the plans.

Page 10-119, Article 1072-6 Anchor Bolts, insert the following after the second paragraph:

Provide stainless steel anchor rods for the machinery grillages meeting the requirements of ASTM A193, Grade B8M, Class 2. Provide a rough-turned surface to remove mill scale, thus resulting in a round bar. Cut or roll the external threads on the rods using the Unified 8-Thread Series, 8 UN-2A, dimensioning as indicated in ANSI B1.1. Produce a rounded thread root and rounded thread crest, so as not to leave notches in the surface of the material.

Provide nonmetallic washers for the machinery grillage anchor rods that are composed of glass-reinforced nylon resin or other approved, with a minimum of 33% glass loading, a minimum elastic modulus of 1,000,000 psi, and a minimum tensile strength of 20,000 psi.

Provide nonmetallic sleeves for the machinery grillage anchor rods that are composed of cold-applied heavy-duty vinyl, moisture-resistant insulating tape. Ensure that the rods are covered adequately with the tape so that the stainless steel does not contact the carbon steel.

Provide stainless steel plate washers for the machinery grillage anchor rods meeting the requirements of ASTM A240, Type 316, with a thickness of 0.1" to 0.18".

Provide stainless steel heavy hex nuts for the machinery grillage anchor rods meeting the requirements of ASTM A194, Grade 8M.

Provide stainless steel self-locking nuts, jam nut system, or approved equal for the machinery grillage anchor rods meeting the requirements of ASTM A194, Grade 8M.

Lubricate the internal threads of the stainless steel nuts and external threads of the stainless steel anchor rods with an anti-galling lubricant. Use a lubricant that is primarily composed of molybdenum disulfide (moly or MoS₂), graphite, mica, or talc. Apply lubricant at the point of assembly.

BRIDGE RAILING

Revise the *2006 Standard Specifications* as follows:

Page 4-85, Article 460-2 Materials, delete the following from the list of items:

Item	Section
Galvanized Steel Rail	1074-5

Page 4-85, Article 460-2 Materials, add the following to the list of items:

Item	Section
Sand Lightweight Concrete	See Special Provision for Sand Lightweight Concrete

Page 4-85, Article 460-3 Construction Methods, Subarticle 460-3(A) Metal Rail, replace the first sentence with the following:

Use aluminum rail on all structures on the project on which metal rail is required.

Page 4-87, Article 460-4 Measurement and Payment, add the following to the list of pay items:

Pay Item	Pay Unit
1'-0" X 1'-6" Concrete Parapet (Sand Ltwt)	Linear Foot

CLASS S CONCRETE

Revise the *2006 Standard Specifications* as follows:

Page 10-5, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(B) Air Entrainment, add the following after the first paragraph:

Do not vibrate or air entrain Class S concrete.

Page 10-6, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Table 1000-1, add the following to the table:

Class of Concrete	S
Minimum Compressive Strength at 28 days, psi	3000 ⁽¹⁾
Maximum Water-Cement Ratio	
Air-Entrained Concrete, Rounded Aggregate	---
Air-Entrained Concrete, Angular Aggregate	---
Non Air-Entrained Concrete, Rounded Aggregate	0.550
Non Air-Entrained Concrete, Angular Aggregate	0.594
Consistency Max. Slump, Inches	
Vibrated.....	---
Non-Vibrated	6-8
Min. Cement Content, Lbs/Yd ³	
Vibrated.....	---
Non-Vibrated	640

(1) Provide mix with laboratory test results of compressive strength at 28 days of at least 4000 psi for laboratory trial batches. If the combination of concrete materials proposed for use will not provide the required laboratory compressive strength, the total cementitious material may be

increased not to exceed 640 lbs. per cubic yard with the approval of the engineer and at no cost to the Department.

Page 10-7, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(D) Temperature Requirements, add the following after the second paragraph:

For Class S concrete, the concrete temperature at the time of placing shall be not less than 40 degrees F nor more than 75 degree F. Do not deposit Class S concrete under water when the water temperature at the surface is less than 35 degrees F.

Page 10-7, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(E) Elapsed Time for Placing Concrete, add the following after the second paragraph:

Place Class S concrete before the time between adding the mixing water to the mix and placing the concrete in the forms does not exceed one hour and forty-five minutes.

Page 10-8, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(F) Use of Set Retarding Admixtures, add the following after the second paragraph:

For Class S concrete, use an approved set-retarding water-reducing admixture.

Page 10-9, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(I) Use of Fly Ash, add the following after the first paragraph:

For Class S concrete, use fly ash in the amount of 25-30 percent by weight of the total cementitious material (Portland cement plus fly ash).

Page 10-9, Article 1000-4 Portland Cement Concrete for Structures and Incidental Construction, Subarticle 1000-4(J) Use of Ground Granulated Blast Furnace Slag, add the following after the first paragraph:

Do not use granulated blast furnace slag in Class S concrete.

STEEL PIPE PILES

Revise the 2006 *Standard Specifications* as follows:

Page 10-215, Article 1084-1 Bearing Piles, Subarticle 1084-1(B) Steel Bearing Piles, Item (2) Steel Pipe Piles, add the following after the first paragraph:

Pipe fabricated with spiral welds is permitted. Use continuous welds to splice the pile. Do not locate transverse splices within 5 feet of the normal water level. Provide chill rings at transverse splice locations for backing of welds.

STEEL GRID DECK

1.0 DESCRIPTION

This work involves the installation of the new steel grid deck of the open type and partially-filled type on the bascule spans as indicated in the plans.

2.0 MATERIALS

Steel grid deck – Fabricate steel grid deck from ASTM A709 Gr. 50 or ASTM A572 Gr. 50 and in conformance with Section 1072 and the details provided in the plans. Provide steel grid deck meeting the following minimum section moduli for the steel only: $S_{top} = 4.98 \text{ in}^3/\text{ft}$ and $S_{bot} = 7.68 \text{ in}^3/\text{ft}$.

Provide welded studs for skid resistance on the open steel grid deck, as shown in the plans. Provide traction grooves on top surfaces of the open steel grid deck elements indicated in the plans with a pattern of 1 inch center-to-center (max.), where possible. Provide an open steel grid deck with a skid resistance number (SN) of 53 at 40 mph when tested uncoated and without welded studs in accordance with ASTM E274.

Galvanize in accordance with ASTM A123. Repair any defects in galvanizing in accordance with ASTM A780. Do not use materials containing aluminum to restore defective areas.

Metal form pans – Provide vertical steel sheet metal form pans that conform to the latest specification of ASTM A366 or A1011. Provide bottom sheet metal form pans of galvanized metal conforming to ASTM A653.

Concrete – Sand lightweight concrete in accordance with the Special Provision for Sand Lightweight Concrete, except use a maximum coarse aggregate that does not exceed 3/8" in size.

3.0 QUALITY ASSURANCE

Use manufacturer of steel grid deck conforming to the following:

1. Current member of the Bridge Grid Flooring Manufacturers Association (BGFMA).
2. American Institute of Steel Construction (AISC) certification for Simple Steel Bridge Structures (SBR).
3. AASHTO/AWS D1.5 Bridge Welding Code.
4. Provide AWS certified welding inspector during manufacturing.

4.0 SUBMITTALS

Within 10 days after the contract is awarded, notify the Engineer of the name, address, telephone number, and contact person of the steel grid fabricator of all deck panels to be manufactured, supplied, and installed.

Prior to beginning fabrication, submit shop drawings showing product detail, concrete mix design, bridge deck layout, dimensions, joining details including cross-section, fastening details, adjacent construction interface, and all other fabrication and installation details for approval. Perform field measurements prior to preparation of the shop drawings.

5.0 STORAGE AND HANDLING

Deliver the steel grid deck to the job site free of any defects and bearing proper identifying marks.

Store steel grid deck at the bridge site above ground in a dry, protected, and well-ventilated area. Keep steel grid deck free from dirt, grease, other foreign matter, and corrosion. Support steel grid deck and materials on platforms, skids, or other supports to maintain any fabrication camber and/or design flatness and to prevent distortion.

Do not overstress the steel grid deck units during lifting and assembly. Submit lifting locations and lifting procedures for review and approval by the Engineer. Avoid twisting or bending of the steel grid deck in the weak (perpendicular to the main bar) direction. Do not lift the steel grid deck from the cross bars, distribution bars, or supplemental bars.

6.0 FABRICATION AND INSTALLATION

Perform welding in conformance with established grid industry practice, including the permitted use of Gas Metal Arc Welding (MIG). Approve weld qualification and weld procedures in conformance with AWS D1.5 prior to steel grid deck fabrication. Use electrodes that are compatible with the steel used for the grid deck.

Fabricate steel grid deck in accordance with the BGFMA shop practices. Fabricate the steel grid deck in accordance with the most recent version of BGFMA TS-01, "Fabrication Tolerances for Grid Decks", published by the BGFMA.

Assemble the steel grid deck such that the tops of all elements are in the same plane. Notching (other than traction grooves) of the main bar top flange is not permitted. Notching the bottom of the cross bar or substitution of a rectangular pattered grid is not permitted. Weld the steel grid deck at all intersections.

For the partially-filled steel grid deck, install vertical steel sheet metal form pans in the grid prior to galvanizing. Install bottom sheet metal form pans after galvanizing and fit metal forms tightly to retain the concrete and prevent excessive leakage. Protect all sheet metal form pans during shipment and store to retain their shape until grid deck installation.

Install the steel grid deck in accordance with the plans, specifications, approved shop drawings, manufacturer's installation standards, and the most recent version of BGFMA TS-02, "Installation Tolerances and Guidelines for Open Grid Decks," or BGFMA TS-03, "Installation Tolerances and Guidelines for Grid Reinforced Concrete Bridge Decks," published by the BGFMA.

Field-assemble multiple panels of the steel grid deck for proper fit before welding the grid deck to the supports. Place the steel grid deck panels on the structure with careful consideration given to the alignment of each adjacent panel. Measure from fixed points to avoid cumulative error.

Ensure that steel grid deck panels are straight prior to installation. If straightening is required, use methods that will not injure the metal and are approved by the Engineer. Obtain the Engineer's approval prior to commencing straightening.

Connect the steel grid deck to the steel supports by welding as indicated in the plans and in conformance with the manufacturer's recommendations. Before any welding is performed, load or clamp the steel grid deck to make a tight joint with full bearing.

Repair all welds and areas of galvanizing damaged during the installation of the steel grid deck in accordance with Section 1076.

Place, cure, and finish concrete in accordance with *2006 Standard Specifications* Section 420 – Concrete Structures. If the concrete is cast-in-place, do not place concrete until steel grid deck is secured in the proper position on the bridge.

During concrete placement, thoroughly clean any concrete seepage around the metal forms or on the structural steel with a high pressure water hose prior to setting of the concrete. Do not disturb the metal forms with the high pressure water stream.

Consolidate concrete by vibrating the steel grid deck. Submit the vibrating device and the manner of operation to the Engineer for review and approval.

Remove and repair all unsatisfactory concrete as directed by the Engineer.

7.0 MEASUREMENT AND PAYMENT

The open steel grid deck and partially-filled steel grid deck will be measured and paid for at the contract unit price per square foot for "Open Steel Grid Deck" or "Partially-Filled Grid Deck", respectively. Such payment will be compensation for furnishing all material, labor, tools, and equipment necessary to perform the work in accordance with the plans, complete in place and accepted.

Cost of testing for skid resistance is also included with the item "Open Steel Grid Deck."

The cost for furnishing all material, labor, tools, and equipment necessary to provide the removable deck panels as shown on the plans is included with the item "Open Steel Grid Deck" or "Partially-Filled Steel Grid Deck".

The steel plate under the sidewalk of the bascule span will not be measured and will be considered incidental to the "Open Steel Grid Deck".

The expansion dam at the midspan of the bascule span and the studded weldment at the joint with the fixed span are not included with this item.

Payment will be made under:

Pay Item	Pay Unit
Open Steel Grid Deck	Square Foot
Partially-Filled Steel Grid Deck	Square Foot

ACCESS SYSTEM

1.0 DESCRIPTION

Furnish, fabricate, and install all fiberglass-reinforced plastic (FRP) items necessary for the complete access system as indicated in the plans. Also included with this item are the fabrication and installation of the floor access hatches in Pier 1 and Pier 6, installation of ladder fall protection systems at Piers 1 and 2 at the locations indicated herein, installation of stair nosing on all concrete staircases, and installation of doors in the bascule piers as listed and described on the plans.

2.0 DEFINITIONS

Access System – The system of walkways, ladders, platforms, handrails, and any other component with the primary purpose of providing access or safety for personnel during inspection or maintenance. All components meeting these requirements and their appurtenances constitute the access system, unless otherwise noted herein.

3.0 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

Provide an access system meeting the applicable requirements of the Occupational Safety and Health Standards.

4.0 MATERIALS

Fiberglass-reinforced plastic (FRP) – Provide items composed of fiberglass reinforcement and resin in accordance with the Special Provision for Fiberglass-reinforced Plastic (FRP) Components.

Floor access hatches – Provide floor access hatches in accordance with the Special Provision for Floor Access Hatches.

Ladder fall protection system – Provide a system that consists of a cable sleeve that follows the climber on a stainless steel cable during ascent or descent on the ladder, but locks in place during the event of a fall. Provide a system that meets all applicable OSHA requirements. Supply four full-body safety harnesses, carabineers, and safety sleeves.

Abrasive nosing – Provide abrasive nosing on concrete stairs that is composed of cast iron or cast aluminum with a minimum thickness of 3/8". Provide nosing with silicon carbide abrasive and cross-hatching on the surface. Attach abrasive nosing to stairs using cast-in anchors.

Threaded rod – ASTM A193, Type 316 Stainless Steel, Grade B8M.

Structural steel – In accordance with the *2006 Standard Specifications* Section 440 – Steel Structures, and as modified herein.

Adhesive anchors – In accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures, the Special Provision for Adhesively Anchored Anchor Bolts or Dowels, and these Special Provisions. Provide adhesive anchors that are suitable for horizontal application, where required.

5.0 FABRICATION AND INSTALLATION

Fabricate and install the FRP access system in accordance with the Special Provision for Fiberglass-reinforced Plastic (FRP) Components.

Fabricate and install the floor access hatches in accordance with the Special Provision for Floor Access Hatches.

Install ladder fall protection systems at ladders that access the sump pumps on Piers 1 and 2 in accordance with manufacturer's installation instructions. Connect the cable to the ladder using brackets and cable guides as recommended by the manufacturer.

Install abrasive stair nosing on all concrete staircases on Piers 5 and 6 and in accordance with the manufacturer's written installation instructions.

6.0 MEASUREMENT AND PAYMENT

The access system will not be measured, but will be paid for on a lump sum basis. Payment will include all costs associated with furnishing, fabricating, and erecting the access system, including all FRP items, floor access hatches, ladder fall protection systems, doors, and connecting hardware. All steel items and fasteners necessary for the support of the Center Lock Maintenance Platform are also included with this item.

Concrete stairs are not included with this item.

Payment will be made under:

Pay Item	Pay Unit
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Access System

Lump Sum

FIBERGLASS-REINFORCED PLASTIC (FRP) COMPONENTS

1.0 DESCRIPTION

Furnish, fabricate, and install all fiberglass-reinforced plastic (FRP) items, with all appurtenances, accessories, and incidentals necessary to produce a complete, operable, and serviceable installation, and in accordance with the requirements of the contract documents.

2.0 SUBMITTALS

Furnish shop drawings of all fabricated FRP items and accessories in accordance with the provisions of this Section.

Furnish manufacturer's shop drawings clearly showing material sizes, types, styles, part or catalog numbers, complete details for the fabrication and erection of components including, but not limited to, location, lengths, type and sizes of fasteners, clip angles, member sizes, and connection details.

Submit the manufacturer's published literature including structural design data, structural properties data, grating load/deflection tables, corrosion resistance tables, certificates of compliance, test reports as applicable, concrete anchor systems and their allowable load tables, and design calculations sealed by a Professional Engineer in the State of North Carolina for systems not sized or designed in the contract documents.

Submit sample pieces of each item specified herein for acceptance by the Engineer as to quality and color. Sample pieces shall be manufactured by the method to be used in the Work.

3.0 QUALITY ASSURANCE

All FRP items to be provided under this item shall be furnished only by manufacturers having a minimum of 10 years experience in the design and manufacture of similar products and systems. Additionally, if requested, provide a record of at least 5 previous, separate, similar successful installations in the last 5 years.

Provide a 3-year limited manufacturer's warranty on all FRP products against defects in material and workmanship.

Provide proof of certification to the ISO 9001:2000 standard.

Provide proof of certification from at least two other quality assurance programs for the manufacturer's facilities or products (UL, DNV, ABC, USCB, AARR).

Provide proof, via independent testing less than six months old, that FRP materials proposed as a solution do not contain heavy metals in amounts greater than that allowed by current EPA requirements.

4.0 PRODUCT DELIVERY AND STORAGE

Deliver manufactured FRP materials in original, unbroken pallets, packages, containers, or bundles bearing the label of the manufacturer. Crate or box adhesives, resins and their catalysts and hardeners separately and noted as such to facilitate their movement to a dry indoor storage facility.

Carefully handle all materials to prevent them from abrasion, cracking, chipping, twisting, other deformations, and other types of damage. Store adhesives, resins and their catalysts in dry indoor storage facilities between 70 and 85 degrees Fahrenheit until they are required.

5.0 MATERIALS

Provide all FRP items furnished under this Section in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.

(A.) Molded FRP Grating

1. Manufacture

Grating shall be of a one piece molded construction with tops and bottoms of bearing bars and cross bars in the same plane. Grating shall have a square mesh pattern providing bidirectional strength. Reinforce grating with continuous rovings of equal number of layers in each direction. The top layer of reinforcement shall be no more than 1/8" below the top surface of the grating so as to provide maximum stiffness and prevent resin chipping of unreinforced surfaces. Percentage of glass (by weight) shall not exceed 35% so as to achieve maximum corrosion resistance, and as required to maintain the structural requirements of the Contract.

After molding, no dry glass fibers shall be visible on any surface of bearing bars or cross bars. All bars shall be smooth and uniform with no evidence of fiber orientation irregularities, interlaminar voids, porosity, resin-rich or resin-starved areas.

Grating bar intersections are to be filleted to a minimum radius of 1/16" to eliminate local stress concentrations and the possibility of resin cracking at these locations.

Provide resins that are isophthalic polyester, with chemical formulations as necessary to provide the corrosion resistance, strength and other physical properties as required.

Fiberglass reinforcement shall be continuous roving in sufficient quantities as needed by the application and/or physical properties required.

Finish all surfaces of FRP items and fabrications smooth, resin-rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. Cover all glass fibers with resin to adequately protect against their exposure due to wear or weathering.

2. Non-slip Surfacing

Manufacture grating with a concave, meniscus profile on the top of each bar providing maximum slip resistance.

3. Fire Rating

Grating shall be fire retardant with a tested flame spread rating of 25 or less when tested in accordance with ASTM E84. Data performed only on the resin is not acceptable.

Gratings shall also have tested burn time of less than 30 seconds and an extent of burn rate of less than or equal to 10 millimeters per ASTM D635.

4. Corrosion Resistance

Manufacturer may be required to submit corrosion data from tests performed on actual grating products in standard chemical environments. Corrosion resistance data of the base resin from the manufacturer is not a true indicator of grating product corrosion resistance and shall not be accepted. List the U.L. classification if available for the grid configuration and surface specified.

5. Color

Dark gray.

6. Load/Deflection

Grating design loads shall be less than manufacturer's published maximum recommended loads. Determine maximum recommended loads by acoustic emission testing. Design grating for a uniform load of 100 psf or concentrated load of 300 lb. Deflection is not to exceed 0.375" or $L/D = 120$, whichever is less.

Provide certification from the manufacturer that the stiffness of all panels manufactured is never more than 2.5% below the published load-deflection values.

7. Measurements

Supply grating that meets the dimensional requirements and tolerances as shown or specified. Provide and/or verify measurements in field for work fabricated to conform to field conditions as required by grating manufacturer to complete the

work. Determine correct size and locations of required holes or cutouts from field dimensions before grating fabrication.

8. Layout

Each grating section shall be readily removable, except where indicated on plans. Manufacturer to provide openings and holes where located on the contract drawings. Grating openings which fit around protrusions (pipes, cables, machinery, etc.) shall be discontinuous at approximately the centerline of opening so each section of grating is readily removable.

9. Sealing

Coat all shop-fabricated grating cuts with vinyl ester resin to provide maximum corrosion resistance. Coat all field-fabricated grating cuts in a similar manner and in accordance with the manufacturer's instructions.

10. Hardware

Provide Type 316 stainless steel hold down clips and space at a maximum of four feet apart with a minimum of four per piece of grating, or as recommended by the manufacturer.

(B.) Molded Stair Treads

1. Manufacture

Stair treads shall be of a one piece molded construction and shall have a rectangular mesh pattern providing unidirectional strength in the tread span direction. Reinforce treads with continuous rovings in each direction. The top layer of reinforcement shall be no more than 1/8" below the top surface of the tread so as to provide maximum stiffness and prevent resin chipping of unreinforced surfaces. Percentage of glass (by weight) shall not exceed 35% so as to achieve maximum corrosion resistance, and as required to maintain the structural requirements of the Contract.

After molding, no dry glass fibers shall be visible on any surface of bearing bars or cross bars. All bars shall be smooth and uniform with no evidence of fiber orientation irregularities, interlaminar voids, porosity, resin-rich or resin-starved areas.

Provide resins that are isophthalic polyester, with chemical formulations as necessary to provide the corrosion resistance, strength, and other properties as required.

2. Non slip Surfacing

Manufacture stair treads with a concave, meniscus profile on the top of each bar providing maximum slip resistance. Manufacture stair treads with a solid, molded nosing gritted with an angular quartz grit that is integrally molded into the top surface of the nosing area only.

3. Fire Rating

Stair treads shall be fire retardant with a tested flame spread rating of 25 or less when tested in accordance with ASTM E84. Data performed only on the resin is not acceptable.

4. Corrosion Resistance

Manufacturer may be required to submit corrosion data from tests performed on actual stair tread products in standard chemical environments. Corrosion resistance data of the base resin from the manufacturer is not a true indicator of stair tread product corrosion resistance and shall not be accepted.

5. Color

Dark gray.

6. Load/Deflection

Stair treads shall meet manufacturer's published recommended loading and deflection requirements.

Provide certification from the manufacturer that the stiffness of all panels manufactured is never more than 2.5% below the published load-deflection values.

7. Measurements

Supply stair treads that meet the dimensional requirements and tolerances as shown or specified. Provide and/or verify measurements in field for work fabricated to conform to field conditions as required by stair tread manufacturer to complete the work. Determine correct size and locations of required holes or cutouts from field dimensions before fabrication.

8. Sealing

Coat all shop-fabricated stair tread cuts with vinyl ester resin to provide maximum corrosion resistance. Coat all field-fabricated stair tread cuts in a similar manner in accordance with the manufacturer's instructions.

9. Hardware

Provide Type 316 stainless steel hold down clips and space at a maximum of four feet apart with a minimum of four per piece of tread, or as recommended by the manufacturer.

(C.) Pultruded Structural Shapes and Handrails

1. Manufacture

Manufacture all structural shapes, posts, and handrails by the pultrusion process with a glass content minimum of 45%, maximum of 55% by weight. Provide structural shapes, posts and handrails that are composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.

Provide resins that are non-fire retardant isophthalic polyester with chemical formulation necessary to provide the corrosion resistance, strength and other physical properties as required.

Fiberglass reinforcement shall be a combination of continuous roving, continuous strand mat, and surfacing veil in sufficient quantities as needed by the application and/or physical properties required.

Finish all surfaces of FRP items and fabrications smooth, resin-rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. Cover all glass fibers with resin to adequately protect against their exposure due to wear or weathering.

2. Ultraviolet Protection

Protect all pultruded structural shapes, posts, and handrails from ultraviolet (UV) attack with 1) integral UV inhibitors in the resin and 2) a synthetic surfacing veil to produce a resin-rich surface. For handrails used in exterior applications, also apply an appropriate UV resistant coating to the top handrail only.

3. Fire Rating

All fire retardant FRP products shall have a tested flame spread rating of 25 or less per ASTM E84 Tunnel Test.

4. Mechanical Properties

Pultruded structural shapes, posts, and handrails are to have the minimum longitudinal mechanical properties listed below:

Property	ASTM Method	Value
Tensile Strength	D638	30,000 psi
Tensile Modulus	D638	2.5 x 10 ⁶ psi
Flexural Strength	D790	30,000 psi
Flexural Modulus	D790	1.8 x 10 ⁶ psi
Flexural Modulus (Full Section)	N/A	2.8 x 10 ⁶ psi
Short Beam Shear (Transverse)	D2344	4,500 psi
Shear Modulus (Transverse)	N/A	4.5 x 10 ⁵ psi
Coefficient of Thermal Expansion	D696	4.4 x 10 ⁻⁶ in/in/°F
Flame Spread	E84	25 or less

5. Measurements

Provide structural shapes supplied that meet the minimum dimensional requirements as shown or specified. Provide and/or verify measurements in field for work fabricated to conform to field conditions as required by manufacturer to complete the work. Determine correct size and locations of required holes or coping from field dimensions before structural shape fabrication.

6. Design Loads

The completed handrail installation shall meet the following load requirements with a minimum factor of safety of 2.0:

Concentrated Load: 200 lb applied in any direction at the top rail.

Uniform Load: 50 lb/lf of the top rail in any direction.

Loads are assumed not to act concurrently.

7. Color

All rails, posts, kickplates, and structural shapes are to be integrally pigmented dark gray.

8. Sealing

Coat all shop-fabricated cuts or drilling with vinyl ester resin to provide maximum corrosion resistance. Coat all field-fabricated cuts or drilling in a similar manner in accordance with the manufacturer's instructions.

9. Hardware

Provide Type 316 stainless steel bolts. Provide 18-8 stainless steel rivets.

10. Fabrication

The handrail post/rail connection is to be fabricated such that the rails are unbroken and continuous through the post without the use of packs or splices. The bottom rail is to be installed through the post at a prepared hole made to fit the outside dimensions of the rail. The top rail is to fit into a machined, u-shaped pocket formed into top of the post such that the rail is located at the center of the post. All exposed post corners are to be radiused to eliminate sharp edges. The rails are to be joined to the post through a combination of bonding and riveting. No sharp, protruding edges are to remain after assembly of the handrail. Spacing of the posts shall not exceed 6'-0".

Do not use PVC or CPVC connectors as a load carrying component of the handrail system.

11. Splicing

When required, splice rails using a 10" length of FRP square tube bonded and riveted into place using epoxy adhesive and 18-8 stainless steel rivets.

(D.) Pultruded Ladders

1. Manufacture

All ladder side rails, rungs, and ladder mounting brackets are to be FRP structural shapes manufactured by the pultrusion process. Provide all structural shapes that are composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.

Provide resins that are isophthalic polyester with chemical formulation necessary to provide the corrosion resistance, strength and other physical properties as required.

Fiberglass reinforcement shall be a combination of continuous roving, continuous strand mat, bi-directional roving mat and surfacing veil in sufficient quantities as needed by the application and/or physical properties required.

Finish all surfaces of FRP items and fabrications smooth, resin-rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. Cover all glass fibers well with resin to protect against their exposure due to wear or weathering.

2. Ultraviolet Protection

Protect all pultruded ladder components from ultraviolet (UV) attack with 1) integral UV inhibitors in the resin and 2) a synthetic surfacing veil to help produce a resin rich surface. For ladders used in exterior applications, also apply an appropriate UV resistant coating to all ladder components.

3. Fire Rating

All fire retardant FRP products shall have a tested flame spread rating of 25 or less per ASTM E84 Tunnel Test.

4. Fabrication

The rungs shall be circular pultruded structural shapes, continuously fluted to provide a non-slip surface. Rungs that are gritted as a secondary operation are not permitted. Fabricate ladder wall and floor mount from pultruded angles.

All rungs shall be both mechanically attached to the ladder with stainless steel rivets and chemically bonded with epoxy.

All rungs shall penetrate the wall of the tube side rails and shall be connected to the rails with both epoxy and rivets to provide both a chemical and mechanical lock, respectively.

Ladders shall be fully shop-assembled.

5. Color

All ladder components, including wall and floor mount brackets, are to be integrally pigmented dark gray.

6. Mechanical Properties

Pultruded structural shapes used in the ladder system are to have the minimum longitudinal mechanical properties listed below:

Property	ASTM Method	Value
Tensile Strength	D638	30,000 psi
Tensile Modulus	D638	2.5×10^6 psi
Flexural Strength	D790	30,000 psi
Flexural Modulus	D790	1.8×10^6 psi
Flexural Modulus (Full Section)	N/A	2.8×10^6 psi
Short Beam Shear (Transverse)	D2344	4,500 psi
Shear Modulus (Transverse)	N/A	4.5×10^5 psi
Coefficient of Thermal Expansion	D696	4.4×10^{-6} in/in/°F
Flame Spread	E84	25 or less

7. Sealing

Coat all shop-fabricated cuts with vinyl ester resin to provide maximum corrosion resistance. Coat all field-fabricated cuts in a similar manner in accordance with the manufacturer's instructions.

8. Hardware

Provide Type 316 stainless steel bolts for attaching wall brackets to the ladder.

Provide Type 316 stainless steel for all fasteners to be used in the ladder system.
Provide 18-8 stainless steel rivets.

6.0 INSPECTION

Provide a smooth finish (except for grit top surfaces) and that is as free, as commercially possible, from visual defects such as foreign inclusions, delamination, blisters, resin burns, air bubbles and pits.

7.0 INSTALLATION

Install all FRP components in accordance with the manufacturer's instructions. Follow manufacturer's instructions when cutting or drilling fiberglass products or using resin products. Provide adequate ventilation.

Fasten grating panels securely in place with hold down fasteners as specified herein.

FLOOR ACCESS HATCHES

1.0 DESCRIPTION

This work is furnishing and installing the floor access hatches in Pier 1 and Pier 6.

2.0 MATERIALS

Provide a floor access hatch that is pre-assembled from the manufacturer, highly corrosion resistant, and not affected by temperature.

Cover – 1/4" minimum aluminum diamond pattern. Reinforce cover to support AASHTO H20 wheel loading with a maximum deflection of 1/150th of the span. If requested, submit design calculations to the Engineer for review and approval. Equip cover with a hold-open arm which automatically locks the cover in the open position.

Frame – 1/4" minimum extruded aluminum channel frame with bend down anchor tabs around the perimeter.

Hinges – Heavy forged Type 316 stainless steel hinges, each having a minimum 1/4" diameter Type 316 stainless steel pin. Provide hinges that are specifically designed for horizontal installation. Fasten hinges to the frame using tamperproof Type 316 stainless steel bolts and locknuts.

Lifting mechanisms – Type 316 stainless steel springs and spring tubes. Provide the required number and size of compression spring operators enclosed in telescopic tubes to

provide smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a check in retarding downward motion of the cover when closing.

Hardware – Type 316 stainless steel. Mount a Type 316 stainless steel slam lock with fixed handle on the underside of the cover. Provide a removable exterior turn/lift handle with a spring-loaded ball detent to open the cover and a flush, gasketed, removable screw plug to protect the latch release.

Finishes – Mill finish aluminum with bituminous coating applied to the exterior of the frame.

3.0 WARRANTY

Provide a manufacturer’s warranty against defects in material and workmanship that is a minimum of 25 years from the date of purchase.

4.0 CONSTRUCTION

Submit shop drawings for review and approval to the Engineer prior to fabrication. Include all profiles, accessories, dimensions and locations on the shop drawings.

Check as-built conditions and verify the accuracy of the details to the fit the application prior to fabrication.

Store materials in a dry, protected, and well-ventilated area.

Prior to installation, verify that the substrate is dry, clean, and free of foreign matter.

Install floor access hatch in accordance with the manufacturer’s recommendations.

REHABILITATION OF PIER 1

1.0 DESCRIPTION

This work includes patching the slab, placing a barrier, placing a grout pad for handrailing, and constructing a concrete wall on Pier 1 as indicated in the plans.

2.0 MATERIALS

Grout – See Project Special Provision for Grout for Structures.

Barrier – Three bar metal rail. In accordance with the *2006 Standard Specifications* Section 460 – Bridge Railing, and as modified herein.

Concrete – Class AA concrete in accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures, and as modified herein.

Reinforcing steel – In accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures, and as modified herein.

Anchor bolts – See plans.

Nuts and washers – In accordance with the *2006 Standard Specifications* Section 440 – Steel Structures, and as modified herein.

3.0 CONSTRUCTION

Patch any surface irregularities or holes in the slab due to the removal of the existing Control House.

Construct grout pad and concrete wall in accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures.

4.0 MEASUREMENT AND PAYMENT

“Rehabilitation of Pier 1” will not be measured, but will be paid for on a lump sum basis. Such payment will be compensation for furnishing all material, labor, tools, and equipment necessary for performing the work complete in place and accepted.

The fabrication and installation of the FRP handrailing, FRP fender access, and the floor access hatch at Pier 1 are not included with this item. See Special Provision for Access System.

Payment will be made under:

Pay Item	Pay Unit
Rehabilitation of Pier 1	Lump Sum

COUNTERWEIGHTS

1.0 DESCRIPTION

This work includes furnishing, fabricating, painting, transporting, and erecting the bascule span counterweights and balance bars.

2.0 MATERIALS

Use materials in accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures, Section 440 – Steel Structures, and as modified by these Special Provisions.

Balance bars – ASTM A36. Galvanize balance bars in accordance with ASTM A123.

Steel ballast – Use steel ballast within the counterweight at locations indicated in the plans. Provide weights of steel ballast in accordance with the weights indicated in the plans.

Provide steel ballast that may or may not conform to a specific classification, but has a unit weight of 490 pcf. Steel produced during continuous casting between the end of one heat of steel and the start of the pouring of the next heat may be used. This steel, referred to as transition steel, is a mixture of two types of steel chemistry.

Clean steel ballast of oil and grease, but do not apply paint coating to steel.

Tie rods – ASTM F1554, Gr. 55.

Neoprene gasket – ASTM D2000 with a durometer hardness of 40 or approved equal. Resistant to salt, water, and deformation under compression. Adhere gasket using adhesive approved by the manufacturer.

Dense styrofoam - Type V of ASTM C578 or approved equal.

3.0 CALCULATIONS

Prepare calculations showing required dimensions and weight of the counterweight based on center of gravity calculations as specified in the Special Provision for New Eastbound Bridge Span Balance. Submit calculations to the Engineer for review and approval, including summarized tabulations showing the total quantity, estimated unit weight, and total weight for each material. Revise these estimates based on the scale weights of all components of each bascule span. Submit the supplemental summarized tabulations to the Engineer for review and approval.

Prior to preparing the balance calculations, cast five test blocks of materials to be used in the counterweights. Each test block shall have a volume of one cubic foot. Prepare and cure test blocks as specified for permanent concrete. Carefully measure and weigh these blocks immediately after casting and again 28 days later. Estimate the unit weight from these measurements.

Verify the unit weight of concrete actually placed in the counterweight by two test blocks made at intervals during the placement of the concrete for each counterweight. Weigh each block promptly after being made and compare the weight to the original test blocks to estimate the resulting unit weight when seasoned, and the need for adjusting the total volume or unit weight of concrete to be placed in the counterweight. If weight adjustments are required for the counterweight, submit the method for adding or removing weight to the Engineer for review and approval.

Perform counterweight calculations assuming that the pockets are filled with the number of balance bars specified on the plans.

4.0 FABRICATION AND INSTALLATION

Place counterweight concrete in lifts that are 2' deep for the first lift and a maximum of 4'-6" deep for subsequent lifts. Cure each lift of concrete for five calendar days prior to the placement of the next lift of concrete.

Paint the exposed surfaces of the counterweight boxes, including the interior surfaces of the counterweight pockets, with the same system that is used on the rest of the bridge.

Store and arrange unused balance bars on dunnage at the designated areas indicated on the plans.

5.0 MEASUREMENT AND PAYMENT

The counterweights will be measured and paid for at the contract unit price per each for "Counterweights." Such payment will be full compensation for furnishing all material, labor, tools and equipment necessary for performing this work complete in place and accepted.

Payment for the balance bars will be at the contract unit price per each for "Balance Bars". Such payment will be compensation for furnishing all material, labor, tools, and equipment necessary for performing the work complete in place and accepted.

Payment for the balancing of the counterweights and bascule span is not included with this item. See the Special Provision for Span Balancing.

Payment will be made under:

Pay Item	Pay Unit
Counterweights	Each
Balance Bars	Each

FENDER SYSTEM

1.0 DESCRIPTION

This work includes the construction of the fender system in accordance with these specifications and in conformity with the lines, grades and locations shown on the plans or as authorized by the Engineer.

2.0 MATERIALS

Steel pipe piles – Provide steel pipe piles conforming to the *2006 Standard Specifications* Section 1084 – Piles, the Project Special Provision for Piles, and the Special Provision for Steel Pipe Piles and with a minimum of 0.20% copper added.

Metallize the exterior of the steel pipe piles with aluminum in accordance with the plans and the Special Provision for Thermal Sprayed Coatings (Metallization).

Sand and gravel fill – Provide a one-to-one mixture of fine and coarse aggregate conforming to the requirements of the *2006 Standard Specifications* Section 1014 – Aggregate for Portland Cement Concrete. A fill consisting solely of fine aggregate may be substituted with the Engineer's approval and at no additional cost.

Structural steel – In accordance with the *2006 Standard Specifications* Section 440 – Steel Structures and as modified by these Special Provisions. Metallize the walers in accordance with the Special Provision for Thermal Sprayed Coatings.

Concrete – In accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures and as modified by these Special Provisions.

Composite rubbing strips – Ultra-high molecular weight (UHMW) polyethylene, crosslinked UHMW resin, averaging 3.1 million – 6 million molecular weight, in full compliance with ASTM D4020 and UV stabilized with 2-1/2 percent carbon black and/or chemical stabilizer, conforming to the following specifications:

Property	Test Method	Acceptance Value
Ultimate Tensile Strength	ASTM D638	5,000 psi minimum
Elongation at Break	ASTM D638	400 percent
Hardness	ASTM D2240	65 Shore D
Abrasion (Steel = 100)	Sand Slurry	10-16
Izod Impact	ASTM D256A	no break
Coefficient of Friction	ASTM D1894	0.20 max

Predrill holes in the rubbing strips so that bolt heads will be recessed a minimum of 1/2" below the surface of the rubbing strip. Provide oversized or slotted holes and gaps in the rubbing strips to account for differential thermal expansion.

Bolts – Stainless steel bolts conforming to ASTM A193, Class 2, Grade B8.

Nuts – Stainless steel nuts conforming to ASTM A194, Grade 6.

Washers – Type 316 stainless steel, 5/16" thick.

3.0 CONSTRUCTION DETAILS

Install pipe piles in accordance with the Special Provision for Piles.

See plans for Suggested Construction Sequence.

4.0 MEASUREMENT AND PAYMENT

“Fender System” will not be measured, but will be paid for at the contract lump sum price, as an acceptably completed unit. Payment includes full compensation for furnishing all labor, materials, equipment, and incidentals necessary to provide the full and complete fender system as described in the plans, Specifications, and these Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
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Fender System

Lump Sum

BASCULE SPAN – ADDITIONAL CONSTRUCTION REQUIREMENTS

1.0 GENERAL

This work includes special erection and fabrication requirements for the bascule span.

2.0 FABRICATION

Camber the bascule girders for dead load and vertical curvature as specified on the plans. Assemble each bascule leaf as a unit in the shop in its cambered position. Perform shop assembly to ensure proper alignment and operation of the bascule span before placement on the bascule pier.

Wherever shims are required, the nominal, or theoretical, thickness "t" shall be indicated. Provide a stainless steel shim pack with a thickness equal to 2 times the nominal thickness indicated and composed of the following material thickness: t, t/2, t/4, t/8, t/16, etc. The thickness of the material furnished shall be such that the total shim pack thickness can be adjusted in increments of 1/32nd inch for machinery bases and structural parts that have machined surfaces, or 1/16th inch for structural steel connections for parts not having machined surfaces.

3.0 ERECTION

Submit complete erection procedures of proposed stages of construction, means of control, and motive power to the Engineer for review and approval. Include estimated displacements and deflections of steel work throughout each phase of erection and concrete placement. Erect the leaves one leaf at a time and perform bolting as soon as practicable, except as required for adjustment. See the Suggested Construction Sequence in the plans.

During periods when the bascule leaves are unbalanced, provide positive, sturdy supports, shoring, and/or falsework to support the unbalanced loads and prevent against accidental rotation. Secure the services of an engineer, registered in the State of North Carolina, to design these supports for the entire unbalanced loads plus all additional loads resulting from wind forces, temporary erection forces, accumulations of snow, ice or dirt, etc. Also design supports for loads eccentric to the vertical axis of the member during all stages of erection. Submit proposed shoring methods, signed and sealed by the Contractor's engineer, to the Engineer for review and approval. Assume responsibility to ensure that the bascule leaves are adequately shored in a safe manner.

Keep ready at a convenient nearby location sufficient counterweight material to balance the bridge leaves during the erection and at completion.

Set all members and other parts which serve as supports or connections of the movable parts or machinery to the tolerances shown on the plans or as called for in the Special Provisions.

Monitor the deflection of the bascule girders during the placement of the concrete in the counterweight. Maintain the shape of the counterweight steel box during placement of the counterweight concrete so as not to allow bulges or distortion that would affect the final balance or operation of the span.

Place and maintain all metal work set in concrete with care in exact alignment at the proper elevation. Do not place concrete around such parts before they are firmly held in place by proper temporary bracing and before the accuracy of the setting has been checked. Where a grout bed is required, adjust and support the metal parts by means of leveling bolts. Provide a grout bed made with an approved self-leveling, high strength non-shrink and non-staining grout. Adjust all metal work to the satisfaction of the Engineer before being set in concrete or mortar.

Ensure that the breaks in the floor are adjusted for smooth joints, proper alignments, and clearances.

4.0 OPERATION

The first time the bascule leaf is moved, check all points of minimal clearance or possible interference between the fixed and movable parts of the structure or as otherwise specified on the plans. Assure that the bascule leaves are opened and closed in a safe manner.

Place the span in an operating condition and to the satisfaction of the Engineer upon its final completion. Operate the span sufficiently to enable the Engineer to satisfactorily conduct inspection of its operation. Repair or replace faulty or defective work at no additional cost to the Owner.

MAINTENANCE AND PROTECTION OF WATERWAY TRAFFIC BENEATH PROPOSED STRUCTURE AT STA. 15+25.75 -L1-

1.0 GENERAL

Maintain navigational traffic on the Pasquotank River at all times during construction.

Maintain fully operational navigation lights on both bridges at all times during and after construction.

Provide a minimum temporary horizontal clearance of 90'-0" with unlimited vertical clearance at all times during construction, unless otherwise permitted by the authority granting the permit.

Submit plans and calculations for review and approval for protecting traffic, as described herein, at the above station before beginning work at this location. Have the plans and

design calculations prepared, signed, and sealed by a Professional Engineer registered in the State of North Carolina. The approval of the Engineer will not relieve the Contractor of the responsibility for the safety of the method or equipment.

2.0 PROTECTION OF TRAFFIC

Protect traffic from any operation that affords the opportunity for construction materials, equipment, tools, etc. to be dropped into the path of traffic beneath the structure. Based on Contractor means and methods determine and clearly define all dead and live loads for this system, which, at a minimum, shall be installed between beams or girders over any navigation area where vessel traffic is maintained. Install the protective system before beginning any construction operations over traffic. In addition, for these same areas, keep the overhang falsework in place until after the concrete barrier rails have been poured.

3.0 BASIS OF PAYMENT

Separate payment will not be made for this item, but will be included with the various pay items which require this work.

BIRD PROTECTION

1.0 DESCRIPTION

This work includes furnishing and erecting a bird repellent system to prevent bird access to the areas indicated in the plans.

2.0 MATERIALS

Metal Screen – Provide Type 316 stainless steel expanded metal screen of size indicated in the plans. Provide Type 316 stainless steel for all framing and stitching and connection hardware.

Bird Spikes – Provide stainless steel bird spikes with pointed tips as manufactured by Nixalite of America, Inc., Bird-B-Gone, Inc., Bird-X, Inc. or an approved equal. Provide stainless steel or other corrosion-resistant material as recommended by the manufacturer for all stitching and connection hardware.

Anchor bolts – Type 316 stainless steel anchor bolts. Adhesively anchor in accordance with the *2006 Standard Specifications* Section 420 – Concrete Structures, the Special Provision for Adhesively Anchored Anchor Bolts or Dowels, and these Special Provisions. Provide adhesive anchors that are suitable for horizontal application, where required.

3.0 FABRICATION AND INSTALLATION

Weld stainless steel in accordance with AWS D1.1 and AASHTO/AWS D1.5. Welding of the metal screen or framing to the superstructure is not permitted.

Grind smooth any burrs, nicks, projections or any rough portions of the metal screen prior to installation. The finished metal screen will have no openings exceeding two inches in any direction.

Attach bird spikes in accordance with the manufacturer's recommendations.

4.0 MEASUREMENT AND PAYMENT

Metal screen and bird spikes, including all work and hardware associated with furnishing and installing these items will not be measured and payment will be made on a lump sum basis.

Payment will be made under:

Pay Item	Pay Unit
Bird Protection	Lump Sum

VERTICAL CLEARANCE GAUGES

1.0 DESCRIPTION

Vertical clearance gauges will be required over the navigational channel of the main bridge.

2.0 CONSTRUCTION REQUIREMENTS

Gauges will be furnished and installed by Division Bridge Maintenance forces within thirty days prior to completion of the main bridge.

Notify, coordinate, and arrange access for Division Bridge Maintenance personnel to complete the work.

3.0 MEASUREMENT AND PAYMENT

No separate measurement will be made of the above work. Payment will be considered as incidental to the construction of the project.

NAVIGATIONAL CLEARANCE VERIFICATION AND WATERWAY INSPECTION

Upon removal of all temporary work bridges, inspect the waterway bottom to insure that all construction waste materials have been completely removed. Remove any bridge-related debris discovered during this survey. Provide a certification in writing by a licensed engineer or licensed surveyor in the State of North Carolina that the waterway has not been impaired and all construction-related debris has been cleared from it. The certification shall include the actual method used to conduct the inspection.

Upon completion of the proposed bridge, verify as-built clearances for the navigational channel and provide a certification by a licensed surveyor or registered professional engineer in the State of North Carolina attesting to the correctness of the clearances.

No separate payment or compensation will be made for this work. Include all costs for performing this work in the various pay items.

CONTROL HOUSE

1.0 DESCRIPTION

This work includes the construction of the control house, excluding reinforced cast-in-place concrete, and electrical work.

The detailed specifications for the Control House are included in Appendix A.

2.0 DEFINITIONS

Control House – The structure on Pier 5 between the roadway level and the rooftop. The Control House includes the Electrical Room and Operator’s Room.

3.0 MATERIALS

Provide materials in accordance with the detailed specifications in Appendix A.

4.0 CONSTRUCTION

Construct the Control House in accordance with the detailed specifications in Appendix A.

5.0 MEASUREMENT AND PAYMENT

Concrete within the Control House will not be included with any of the Control House pay items. See the Special Provision for Concrete Structures.

“Control House – Mechanical” will not be measured, but payment will be made on a lump sum basis. Items in the following detailed specifications in Appendix A are included with this item:

- 22 05 17 SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
- 22 05 18 ESCUTCHEONS FOR PLUMBING PIPING
- 22 05 23 GENERAL-DUTY VALVES FOR PLUMBING PIPING
- 22 05 29 HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
- 22 05 53 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
- 22 07 19 PLUMBING PIPING INSULATION
- 22 11 16 DOMESTIC WATER PIPING
- 22 11 19 DOMESTIC WATER PIPING SPECIALTIES
- 22 13 16 SANITARY WASTE AND VENT PIPING
- 22 33 00 ELECTRIC, DOMESTIC-WATER HEATERS
- 22 42 13.13 COMMERCIAL WATER CLOSETS
- 22 42 16.13 COMMERCIAL LAVATORIES
- 23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
- 23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
- 23 07 13 DUCT INSULATION
- 23 07 19 HVAC PIPING INSULATION
- 23 23 00 REFRIGERANT PIPING
- 23 31 13 METAL DUCTS
- 23 33 00 AIR DUCT ACCESSORIES
- 23 34 23 HVAC POWER VENTILATORS
- 23 37 13 DIFFUSERS, REGISTERS, AND GRILLES
- 23 81 26 SPLIT-SYSTEM AIR-CONDITIONERS

“Control House – Architectural/Structural/General Construction” will not be measured, but payment will be made on a lump sum basis. Items in the following detailed specifications in Appendix A are included with this item:

- 05 12 00 STRUCTURAL STEEL
- 05 31 00 STEEL DECK
- 05 40 00 COLD-FORMED METAL FRAMING
- 05 45 00 PRE-ENGINEERED LIGHT GAUGE STEEL TRUSSES
- 05 52 13 PIPE AND TUBE RAILINGS
- 06 16 00 SHEATHING
- 07 41 10 METAL ROOF PANELS
- 07 41 20 METAL WALL PANELS
- 07 62 00 SHEET METAL FLASHING AND TRIM
- 08 41 13 ALUMINUM ENTRANCES, STOREFRONT, AND GLAZING
- 09 29 00 GYPSUM BOARD ASSEMBLIES
- 09 31 00 CERAMIC TILE
- 09 51 23 ACOUSTIC TILE CEILING
- 09 66 23 RESINOUS MATRIX TERRAZZO FLOORING
- 09 91 20 PAINTING (PROFESSIONAL LINE PRODUCTS)
- 09 91 23 HIGH PERFORMANCE CONCRETE COATINGS

Payment will be made under:

Pay Item	Pay Unit
Control House – Architectural/Structural/ General Construction	Lump Sum
Control House – Mechanical	Lump Sum

NEW EASTBOUND BRIDGE MECHANICAL WORK

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

The work shall include furnishing, manufacture, fabrication, erection, installation, testing and placing into satisfactory service, the mechanical system for operation of the new bascule span, including the span drive gearmotors and auxiliary drive gearmotors, motor and machinery brakes, parallel differential gear reducers, shafts, couplings, rack gear segments and pinions, trunnions, trunnion bearings and pedestals, and machinery support frames. Included as part of the bridge mechanical operating system are the center span lock assemblies, and associated brackets and bushings. Also included as part of the mechanical system is the installation of the tail locks, and associated brackets, linkage, struts, shims, power actuators, and hardware. Supply also the machinery lubricating equipment, and all other associated machinery components necessary to have a complete operating system, all in accordance with AASHTO, the specifications, and the contract drawings, or as directed by the Engineer.

The Contractor shall:

- (A) Provide all apparatus, tools, devices, materials and labor to manufacture, paint, ship, install, erect, align, adjust, lubricate, and test the operating machinery for the bascule span in an approved manner as provided herein. Any apparatus, tools, devices, materials and labor, not specifically stated or included, which may be necessary for the work, shall be furnished by the Contractor.
- (B) Install and adjust all machinery, machinery pedestals, shafts, couplings, and gearing with the use of millwrights experienced in this class of work.

NOTE: Reference to a specific manufacturer, brand, model or catalog number is intended to describe the quality and characteristics of the item or material referenced, and shall not be interpreted as excluding equivalent products by other manufacturers. All proposed substitutions shall be submitted to the Engineer for approval.

1.2 ITEMS OF THE OPERATING MACHINERY

Items, materials, and methods presented in this section for the bridge operating machinery are for the entire bridge, and include:

- (A) For each bascule leaf drive: main drive machinery from and including the main drive gearmotors, auxiliary drive, differential reducer through the pinions and racks on the girders, including main pinions, shafting, trunnions and bearing assemblies, motor brakes and brake wheels and machinery brakes and brake discs, couplings, and component mounting frames as shown in the contract drawings.

- (B) Two span lock assemblies, at the center of the bascule span on the inside of the girders, including: electric power cylinder with brake, lockbar, lockbar guides and receivers, bushings, shims, pins, and support weldments.
- (C) Four tail lock assemblies, two located in each bascule pier, and supporting the rear of the counterweights, including support weldments, linkage, struts, and electric power cylinder drive actuators for each assembly.
- (D) Span centering device, located at mid-span and mounted to the end floor beam on each leaf, associated shims and mounting hardware.
- (E) Keys, bolts, nuts, screws, washers, dowels, filler plates, spacer plates and shims required to assemble all components to the supporting steel framing and provide proper alignment of all mechanical systems, and related electrical components listed below.
- (F) Installation of Electrical items, including main span drive gearmotors, auxiliary drive gearmotors, auxiliary drive coupling shift mechanism, rotary cam limit switches and drive components, and other span control equipment, span opening indicators, and limit switches.

1.3 APPLICABLE STANDARDS

- (A) American Association of State Highway and Transportation Officials (AASHTO) LRFD Movable Highway Bridge Design Specifications, 2nd Edition, 2007 and Later Interim Revisions
- (B) American Society for Testing and Materials (ASTM), latest version of all applicable standards.
- (C) American National Standards Institute (ANSI), latest version of all applicable standards.
- (D) American Gear Manufacturer's Association (AGMA), latest version of all applicable standards.
- (E) Society of Automotive Engineers (SAE), latest version of all applicable standards.
- (F) American Welding Society (AWS), Structural Welding Code, D1.1-2010.
- (G) American Bearing Manufacturers Association (ABMA), latest version of all applicable standards.
- (H) American Iron and Steel Institute (AISI), latest version of all applicable standards.

- (I) American Institute of Steel Construction (AISC), latest version of all applicable standards and specifications.

1.4 SUBMITTALS

(A) General

1. The Contractor shall submit copies of producer or manufacturer data, e.g. specifications, tests results and installation instructions, for items and materials including:
 - (a) Mill reports and physical tests of all metals
 - (b) Bolts, nuts, washers, and other fasteners
 - (c) Paint
 - (d) Lubricants as endorsed by machinery manufacturers
 - (e) Standard and custom-manufactured purchased components
2. The Contractor shall prepare a complete list of all machinery items which require lubrication. The list shall contain the type of lubricant used and the date it was installed and lubricated by the Contractor, and shall be given to the Engineer prior to start up and testing of the machinery.
3. Shop drawings shall indicate the methods and sequences to be employed in the assembly of bridge machinery, and installation of necessary utilities, support and service facilities.

(B) Manufactured Items

1. The Contractor shall submit shop drawings to the Engineer for approval. These shall include complete details, classification of materials, schedules for fabrication and shop assembly, procedures and diagrams showing sequence and details for erection and approval.
2. Shop drawings for manufactured detail parts shall be given a suitable title to describe the parts detailed thereon. Each drawing shall be identified by the complete project name and number, and shall include:
 - (a) Dimensions, call-outs and notes to completely define the form, fit, function, manufacturing process and allowable deviations for each item.

- (b) Material specification for each item.
 - (c) Heat treatment or specific hardness requirements when mandated.
 - (d) The surface finish of machined surfaces and tolerances for each dimension for which a specific fit is required. A general tolerance block shall be used to define the tolerances of all other dimensions. Fits and finishes shall be the more rigorous of AASHTO or manufacturer specifications.
 - (e) Quantity required.
 - (f) Computed weight. Component weights shall be shown on the same shop drawing as the component detail.
3. Shop drawings for fabricated or purchased assemblies shall include:
- (a) Complete data on the design and construction of all detail components furnished as part of the machinery under this Contract as presented in Section B.2 above.
 - (b) All proprietary items (e.g. enclosed reducers, brakes, etc.) shall be shown in outline on shop drawings.
 - (c) Complete assembly diagrams shall be provided for proprietary components that show each part contained within the item and its corresponding manufacturer's part number. The diagrams shall be sufficient to enable complete disassembly and re-assembly of the subject component and enable the definition and procurement of proper spare/replacement parts.

In the event that any part is modified in any manner from the way it is described or delivered by its original manufacturer, the Contractor shall deliver a drawing which details each modification, and the part shall be assigned a unique part number to assure procurement of proper spare/replacement parts.

Component assembly drawings shall include:

1. Certified external dimensions and clearances affecting interfaces or installations
2. Gross weight
3. Capacity and normal operating ratings

4. Method and recommended type of lubrication, including location and type of fittings and provisions for adding, draining and checking the level of each lubricant employed
 5. Inspection openings, seals, and vents
- (d) Complete shop bills of materials shall be included for all machinery parts. If the bills are not shown on the shop drawings, prints of the bills shall be furnished for approval in the same manner as specified for the drawings.
- (e) Complete assembly and erection drawings shall be furnished. These drawings shall provide identification of, and essential locating dimensions for each part or assembly with respect to the bridge or foundation.
4. Shop drawings, which have not been approved or require correction, shall be resubmitted until they are approved by the Engineer. This approval-procedure shall not be considered a cause for delay. The Contractor shall bear all costs or damages which may result from the ordering or fabrication of any materials prior to the acceptance of the shop drawings. As a means of expediting delivery prior to acceptance of the shop drawings, the Contractor may request in writing from the Engineer, approval to order raw materials of the correct type for later fabrication from accepted shop drawings. Such approval by the Engineer shall be in writing. After acceptance of the shop drawings, the Contractor shall supply the Engineer with additional copies of the accepted drawings as may be required.

PART 2 PRODUCTS

2.1 MATERIALS

(A) General

1. Materials and components shall conform to the drawings and referenced standards.
2. Hardness shall be tested and reported, for details with required hardness values.
3. No item shall be fabricated without sufficient advance notice given to the Engineer to permit inspection.

- (a) The Contractor shall furnish all facilities and provide for the free access at the plant or shop for the inspection of material and workmanship.
- (b) Acceptance of a material or item shall not preclude subsequent rejection if defects are found later.
- (c) The Contractor shall furnish the Engineer with of copies of purchase orders as requested.
- (d) Unless otherwise provided, the Contractor shall furnish without charge, test specimens required herein, and all labor, testing machines, tools and equipment necessary to prepare the specimens and to make the physical tests and analyses. Two copies of test reports and chemical analyses shall be furnished to the Engineer.

(B) Manufacturer's Recommendations

When installation procedures for an item or component are required to be in accordance with the recommendation of the manufacturer, printed copies of the recommendations shall be furnished to the Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

(C) Standard Products

1. Materials and equipment shall essentially be standard, current production, cataloged products of established manufacturers, and have at least two years of satisfactory commercial or industrial use prior to bid opening.
2. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer.
3. Each major assembled component shall have a conspicuous, durable, permanently affixed nameplate that includes at least the following information: the manufacturer's name, address, the component model number, serial number, rated capacity and pertinent factory setting(s). The nameplate of the distributing agent will not be acceptable.
4. Materials of equal or greater strength and corrosion resistance than shown on the plans can be proposed and are subject to approval by the Engineer.
5. Electrodes for welding shall comply with AWS Code.

6. Heavy hexagonal head bolts, heavy hexagonal nuts, and hardened washers shall conform to ASTM A325, A563 Grade C, and F436, respectively. ASTM A307 bolts shall not be used.
7. Turned bolts with body diameter greater than 1 ½" shall conform to ASTM A449, unless otherwise specified on the plans.
8. Alloy steel hex socket head cap screws shall comply with ASTM A574. Stainless Steel hex socket head cap screws shall be Type 316, with a minimum tensile strength of 85,000 psi, and shall meet or exceed ASTM F837, Alloy Group 1, Condition CW, unless otherwise specified. Dimensions shall conform to ANSI B18.3.
9. Stainless steel for fasteners and threaded rods where specified shall be Type 316 Stainless Steel, with a minimum tensile strength of 85,000 psi and shall meet or exceed ASTM F593, Alloy Group 2, Condition CW, unless otherwise specified. Stainless steel for hex nuts shall be Type 316, with a minimum tensile strength of 85,000 psi and shall meet or exceed ASTM F594, Alloy Group 2, Condition CW, unless otherwise specified. Stainless Steel washers where specified shall be Type 316. Stainless Steel clevis pins shall be ASTM A276, Type 316, Condition S, Cold Finished. Stainless steel shim material shall be ASTM A240 or A666, Type 316.
10. Equipment covers and guards shall be a minimum 14-gauge sheet stainless steel conforming to ASTM A240, Type 316, welded at corners, adequately stiffened and held rigidly in place.

2.2 DETAILS AND WORKMANSHIP

- (A) The machinery shall be finished, assembled, and adjusted in an approved manner using best shop practice. The limits of accuracy which are to be observed in machining, and the allowances for all metal fits shall be placed on the Contractor's working drawings.
- (B) Where surface finishes are indicated, the symbols used shall conform to ANSI B46.1, "Surface Texture". Roughness specified is the maximum value, and any smoother finish will be satisfactory. Compliance with specified surface will be determined by trained sense of feel and by visual inspection of the work compared to "Standard Roughness Comparisons" in accordance with the provisions of ANSI B46.1. Values of roughness width and waviness are not specified, but shall be consistent with the general type of finish specified by the roughness height. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection.
- (C) Unspecified surface finishes shall conform to AASHTO, Section 6.7.8. Mating surfaces shall be machined to provide even, true bearing. Surfaces with rotating

or sliding contact shall be highly polished and finished true to the given dimensions.

(D) So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Large discrepancies between adjoining unfinished surfaces shall be remedied to realize proper alignment. Depressions or holes not affecting the strength or function of the parts may be filled in a manner approved by the Engineer.

(E) Mechanical Component Requirements

1. Shafting and Pins

- (a) Rounds and shafts shall be true, straight and free from flaws, piping, laps, seams, or cracks. All shafts shall have finished ends with a 60-degree lathe center with a clearance hole at the exact center of the shaft. Stepped shafts shall have fillets finished smoothly to adjacent surfaces without tool marks or scratches. Surface finish for fillets shall have a maximum roughness of 63 micro-inch according to ANSI B46.1, unless a finer finish is required.
- (b) All forged shafts shall be reduced to size from a single bloom or ingot until perfect homogeneity is secured. The blooms or ingots, from which shafts or pins are to be made, shall have a cross-sectional area at least three times that required after finishing. No forging shall be done at less than red-heat. Forged rounds for shafts and pins shall be true, straight, and free from any defect.
- (c) All shafts and pins shall be accurately finished, round, smooth, and straight; and when turned to different diameters, they shall have rounded fillets at the shoulders. Each shaft or pin having a uniform diameter of 8 inches or more and each shaft or pin having several diameters, of which the smallest is 8 inches or more, shall be bored lengthwise through the center to a diameter approximately one fifth the smallest diameter. The wall of the center bore shall be examined for cracks and fissures. Shafts and pins exhibiting defects will not be accepted. Shafts that are bored with an inspection hole shall have the ends prepared for the attachment of a centering device equivalent to the lathe center. All such devices shall be furnished as part of the work.
- (d) All journal bearing areas on shafts and pins shall be accurately turned, ground, and polished with no trace of tool marks or scratches on the journal surface or adjoining shoulder fillets. The journal bearing area shall have an 8 micro-inch finish or better. Journal diameters shall be finished to the limits of an ANSI Class RC6 running fit, unless otherwise noted. Bearing seats on shafts with rolling element

bearings shall have a surface finish of 63 micro-inch, unless otherwise specified by the bearing manufacturer.

2. Keys, Keyways, and Set Screws

- (a) Keys and keyways shall conform to the dimensions and tolerances for square and flat keys of the ANSI Standard B17.1, "Keys and Keyseats," unless otherwise specified. Keys shall be machined for an FN2 side fit (Class 3) and an LC4 fit on top and bottom with keyways in shafts and hubs and a 63 micro-inch finish or better. Keyway corners and key chamfers shall be cut with the fillet radius and chamfer as suggested by ANSI B17.1. All keys shall be effectively held in place, preferably by setting them into closed-end keyways milled into the shaft. The ends of all such keys shall be rounded to a half circle equal to the width of the key. Keyways shall not extend into any bearing. If two keys are used, they shall be located 120 degrees apart.
- (b) Unless otherwise specified herein or on the plans, keys shall be made from steel squares or flats that meet the requirements of ASTM A668, Class L, or equal or greater strength alternative.
- (c) Set screws shall not be substituted for keys for transmitting torsion; they may be used only for holding keys or light parts in place. They shall be safety-type headless set screws with cup points set in counter-bored seats. Unless otherwise ordered, they shall be secured in place by use of self-locking threads.

3. Bearings and Bushings

Self-lubricating (maintenance free) bushings shall be standard products of an established manufacturer.

4. Gears

- (a) Rack gear segments shall be fitted and doweled together accurately. Particular care shall be taken to have the pitch of the teeth accurate at the splices. The periphery of the rack gear teeth shall be planed. The Contractor shall submit to the Engineer for approval, a detailed assembly and alignment procedure for the pinion/ring gear mesh.
- (b) The teeth of all gears shall be cut from solid rims or blanks. The sides and peripheries of all gears and pinions shall be finished, and the pitch circle for the rack and pinion shall be scribed on both sides not less

than 0.02 inches deep, with a V-pointed tool. The contact areas between the back of the rack gear segments and the mounting surfaces on the rack support weldment shall both be finished. The working surfaces of all gear teeth shall be true to the proper outline, accurately spaced on the true pitch circle, exceptionally smooth, and free from planing or milling-cutter ridges. Cutter burrs shall be removed from all edges of the teeth, and the top edges of all teeth shall be rounded to 1/32-inch radius.

- (c) Except as otherwise provided herein or on the plans, all gears shall be cut and mounted to meet requirements for accuracy of the ANSI/AGMA Standard 2000-A88 (or most recent replacement standards), Gear Classification and Inspection Handbook. The AGMA quality number shall be stated on the applicable shop drawings. Open gearing shall conform to minimum AGMA Quality No. 8. Gearing in enclosed gear reducers shall conform to AGMA Quality No. 10 or higher.

5. Hubs and Bores

The hubs of all gears and couplings shall be finished on both faces and polished where the hub face performs the function of a collar to prevent shaft movement. The hubs shall be bored concentric with the rims of gears or with the outside of couplings. Unless otherwise noted or recommended by the manufacturer, all other hubs shall have a 32 micro-inch finish or better for 2 inch or smaller bore, or a 63 micro-inch finish or better for a bore larger than 2 inches.

6. Shims

Where shown on the plans, all machinery shims required for leveling and alignment of equipment shall be stainless steel, ASTM A240 or A666, Type 316, neatly trimmed to the dimensions of the assembled parts and drilled for all bolts that pass through the shims. In general, total shim thickness available shall be no less than equal to twice the nominal thickness shown on the plans, and sufficient varying thicknesses shall be furnished to secure 0.010-inch variations of the shim allowance including one shim equal to the full allowance. Shims shall be placed to provide full contact between machinery and machinery supports. Shims shall be shown in detail on the shop drawings.

7. Turned Bolts

The bodies of turned bolts shall be finished to 63 micro-inches or better, as defined by AASHTO. Threads for the turned bolts and nuts

shall conform to the Unified Thread Standards, coarse thread series with a Class 2A tolerance for bolts and Class 2B tolerance for nuts, in accordance with ANSI B1.1, unless otherwise specified. Turned bolts are designated by their nominal thread size. The turned bolt body shall be 1/16" larger in diameter than the nominal size specified, and shall have an LC6 fit with reamed holes. Bolt head and nut bearing surfaces shall be flat and square with the axis of the bolt holes and shall be spot faced if necessary. Unless otherwise noted, bolt holes in machinery parts required for connecting to supporting steelwork may be sub-drilled (in the shop) smaller than the turned bolt diameter and shall be reamed together with supporting structural steel either during assembly or at erection, after the parts are correctly assembled and aligned. Positive type locking shall be provided. Double nuts are preferred. Where two heavy nuts are not used, heavy hex and jam nuts shall be used. Alternate locking methods shall be submitted to the Engineer for approval.

8. Castings

All castings shall be cleaned free of all loose sand and scale. All fins, seams, gates, risers and other irregularities shall be removed. All unfinished edges of castings shall be neatly cast with rounded corners and all inside angles shall have ample fillets. Dimensions of castings shown on the approved shop drawings will be the finished dimensions. Deviations from the dimensions and the thicknesses of the castings, as shown on the drawings, will not be permitted to exceed such amounts as will, in the opinion of the Engineer, impair the strength of the casting as computed from the dimensions shown. Warped or otherwise distorted castings, or castings that are oversize to such an extent as to interfere with the proper fit with other parts of the machinery, will be rejected. All castings shall be manufactured in accordance with ASTM A781 and shall be tested for internal defects using the applicable examination method prescribed under Supplementary Requirements of ASTM A781.

9. Welding

Welding shall comply with AWS D1.1-2010. Welded steel machinery parts shall be given a stress relief heat treatment prior to machining. The Contractor shall submit a schedule of the proposed stress relief heat treatment to the Engineer for approval. The schedule shall include a description of the part and an explanation of the proposed heat treatment, including the rate of heating, the soaking temperature, the time at the soaking temperature, the rate of cooling, and the temperature at which the part is to be withdrawn from the chamber. Soaking times of less than one hour will not be approved. Welds in

all trunnion hubs, trunnion bearing pedestals, span lock supports, guides and receivers, and all machinery support mounting weldments shall be 100% inspected by non-destructive methods. Acceptance criteria shall be that described in AWS D1.1-2010.

10. Flexible Couplings

- (a) Gear-type, full-flexible (double engagement) couplings or semi-flexible (single engagement) couplings with floating shafts shall be used to connect all machinery components, except where other types of flexible couplings are called for on the plans. The couplings shall be made of forged alloy steel, have exposed bolts, curved face teeth, and provide for at least a 3/4-degree misalignment per gear mesh. Installation misalignment should be limited to no more than 1/8 degree per gear mesh.
- (b) Gear-type couplings shall be the standard product of an established manufacturer.
- (c) Special type couplings shall be as shown on the plans.
- (d) Coupling hubs shall be bored by the coupling manufacturer to the required size and tolerances, including keyways, and each hub shipped to the proper location for installation on its shaft by the manufacturer of the connected component.
- (e) Flexible couplings for the main reducer input shaft shall be double engagement gear couplings with a torque rating of 270,900 lb-in with bores and keyways to match span drive gearmotors and reducer input shafts.
- (f) Flexible couplings for the floating output shafts shall be single engagement gear couplings with centering disks and a torque rating of 1,500,000 lb-in with bores and keyways to match reducer output shafts and pinion shafts.

11. Main Drive Speed Reducers

- (a) Provide two parallel shaft differential reducers as shown in the plans, or approved equal.
- (b) The speed reducers for the main drive machinery shall be designed in accordance with the current AGMA Standards and as shown in the plans. Gear quality shall be class 10 or better. The reducers shall have welded steel housings with adequate inspection openings to permit easy inspection of all gears after installation. The internal and external surfaces of the gearbox shall have an anti-corrosive finish.

Inspection covers shall be attached with stainless steel hardware. The AGMA strength rating shall be based on an overload of 250 percent of the full load torque of one span drive motor operating and shall be equal to the ratings described on the plans. The AGMA durability rating shall be based on single drive gearmotor operation (50 hp at 105 rpm) with a 1.5 service factor. Each reducer shall have a hygroscopic air breather with an adequate filter to prevent particulate matter from entering the housing. The hygroscopic breather shall be mounted so as to prevent oil from leaking out during operation of the bridge. The shaft seals shall incorporate a two stage sealing arrangement. The housings shall be leak-proof and shall be tested in the shop for leakage.

- (c) The bearings required to support the speed reducing gears shall be rolling element type, selected to provide 40,000 hours of B-10 life while transmitting full rated horsepower of one drive motor.
An oil drain shall be provided for each reducer with bronze or stainless steel drain cocks to permit easy withdrawal and replacement of oil.
- (d) The reducers shall have balanced design herringbone or double helical gears for the speed reducing gears, with double shaft extensions for both high speed input and low speed output shafts.
- (e) Shaft Extensions and Couplings: The low and high speed shaft extensions on each side of the reducers shall be of such length and diameter that they may be turned and keyseated for the gear couplings. The input shaft extensions of each reducer shall be of sufficient length and diameter so that they may be turned and keyseated for the motor brake wheels. Brake wheels for the motor brakes and motor coupling halves shall be shipped to the reducer manufacturer for assembly on the main reducer input shaft extensions.
- (f) Nameplate: Speed reducers shall be provided with a permanent AGMA nameplate stating the horsepower rating, speeds, ratio and thermal rating. Manufacturer's nameplate shall include the manufacturer's name, address, model number, and serial number (nameplate of distributing agent will not be acceptable).
- (g) Prior to construction, the manufacturer shall supply to the Engineer for review, a complete set of calculations demonstrating adherence to design criteria presented herein including AGMA ratings.
- (h) Housings shall be sufficiently rigid so that deflection is negligible under full load and will maintain acceptable bearing running

clearances and gear contact. Welded steel housing construction is acceptable, but must be stress relieved by heat prior to machining.

- (i) Reducers shall be the product of a manufacturer of established reputation who has had differential reducers of comparable size and construction in successful service for at least ten years.

12. Span Drive Motor Brakes

- (a) Span drive motor brakes shall be electro-hydraulic thruster type drum brakes, Magnetek/Mondel Hi-Tork 300M, Mill Duty series, 16" diameter, Catalog # 16" MBT/E-ED 121/6, or approved equal. Each brake shall have a low force hand release lever that will permit release of the brake without energizing the thruster motor. Brakes shall be adjustable to independently regulate the time for setting of the brake. One brake shall be provided for each drive motor. The motor brake wheels (two per leaf, four total) shall be mounted and keyed to each input shaft extension of the differential reducer. Each brake shall be factory set for 1400 foot pounds of braking torque and automatically adjust for lining wear. The brakes shall be supplied with stainless steel pivot pins, bearings at all main pivots, and any other optional features necessary for corrosion protection. The brakes shall be painted with a finish coat of Federal Safety Orange prior to final assembly.
- (b) The motor brakes shall operate at 460 volts, 3 phase, 60 Hz. Each motor brake shall be equipped with three separate limit switches for interlocking span control supervision and indications. Two brake limit switches shall provide for sequence interlocking on span control operation and for indication of the set and release status of the brakes. The other brake limit switch shall provide for lock-out of the span control circuitry when any brake is hand released and for indication. Brake limit switches shall be NEMA 4 rated, oil-tight and furnished and mounted on each brake frame by the manufacturer.
- (c) Each motor brake shall operate on a Magnetek/Mondel brake wheel, 16" diameter, 6.75" wide, symmetrical hub with bore and keyslot to match the reducer input shaft, or an approved equal. All exposed surfaces shall be painted as specified elsewhere herein.
- (d) The motor brakes shall be supplied with set delay valve. Brake set delay shall be initially set at 1 second. This delay may be adjusted in the field at the discretion of the Engineer.

- (e) Each motor brake shall have the manual low force brake release lever mounted on the side of the brake that provides the most access for operation.
- (f) Each motor brake shall be supplied with a Type 3R stainless steel cover, with slots for drive shaft, and access to brake release lever without removal of cover. Cover shall have a hinged lid for inspection purposes.

13. Machinery Brakes

- (a) The machinery brakes shall be disc type with two discs per leaf, each operated by two Bubenzer SB28 electro-hydraulic thruster, disc brake units, or approved equal. The brakes shall operate on discs that are 1000 mm diameter. Each thruster brake unit shall have a low force hand release lever that will permit release of the brake without energizing the thruster motor. Brakes shall be adjustable to independently regulate the time for setting of the brake. Each thruster brake unit shall be factory set for 12,170 foot pounds of braking torque and automatically adjust for lining wear. The brakes shall be supplied with stainless steel pivot pins, bearings at all main pivots, lube fittings, and any other optional features necessary for corrosion protection. The brakes shall be painted with a finish coat of Federal Safety Orange prior to final assembly.
- (b) The machinery brakes shall operate at 460 volts, 3 phase, 60 Hz. Each machinery brake shall be equipped with three separate limit switches for interlocking span control supervision and indications. Two brake limit switches shall provide for sequence interlocking on span control operation and for indication of the set and release status of the brakes. The other brake limit switch shall provide for lock-out of the span control circuitry when any brake is hand released and for indication. Brake limit switches shall be NEMA 4 rated, oil-tight and furnished and mounted on each brake frame by the manufacturer.
- (c) Each machinery brake shall be mounted at the inboard end of each main pinion shaft, and operate on a 1000 mm disc, with specially fabricated hub and backing plate. The hub key slot shall match the pinion shaft. All exposed surfaces shall be painted as specified elsewhere herein.
- (d) The machinery brakes shall be supplied with set delay valve. Brake set delay shall be initially set at 2 seconds. This delay may be adjusted in the field at the discretion of the Engineer.

- (e) Each machinery brake (consisting of two thruster units) shall be supplied with a Type 3R stainless steel cover, with slots for drive shaft, and access to brake release lever without removal of cover. The cover shall have a hinged lid for inspection purposes.

14. Trunnions, and Trunnion Bearings

(a) Girder/Trunnion

Each bascule leaf girder is assembled with a trunnion shaft and two trunnion bearings. The girder connection hub shall be fabricated by welding, and made of alloy steel, as specified on the contract drawings.

(b) Trunnion Pillow Block Bearings

Each trunnion bearing consists of a cast steel base and cap fitted with internally mounted split plain journal bearings.

(c) Trunnions

The trunnions shall be made of forged alloy steel, ASTM A291, Class 6 (finished all over). The ends of each trunnion shall fit into the trunnion bearings, and be in exact alignment under full dead load. The journal ends of each trunnion shall be turned with extreme care to the diameter and length so that the bearing centerlines are at the required center to center distance of the trunnion bearings. One end of one trunnion shaft in each leaf shall be machined to accommodate an adapter shaft to drive the span control equipment.

(d) Girder-Trunnion Assembly

The trunnions shall be fit into the trunnion/girder hub with a shrink fit as specified on the contract plans. The trunnion shall be positioned on the trunnion hub and then drilled and doweled in place using high strength "Unbrako" (or equal), 150,000 psi shear strength steel dowels. The dowel holes are to be peened after assembly. Use of "Vent type" dowels is advisable.

(e) Erection

The girder/trunnion assembly and trunnion bearings shall be adjusted so that both trunnions on each bascule leaf are accurately aligned. The alignment of the trunnions shall be obtained vertically and horizontally such that, when the full dead load is on the span, the axes of the two trunnions in each leaf will be a straight horizontal line at right angles to the centerline of the bridge. Vertical adjustment shall

be obtained by use of full size shims. In setting the girder/trunnion and bearings, allowance shall be made for the anticipated transverse and longitudinal movement of the assemblies under the deformations of all the supporting members due to the total dead load of the span, including counterweights. The Contractor shall submit a detailed assembly and alignment procedure for installation of the trunnion assemblies to the Engineer for approval.

Bolts connecting the trunnion bearings to the bearing pedestals shall be ASTM A449 high strength turned bolts in reamed holes, with an LC6 fit.

15. Pinions and Rack Gear Segments

- (a) The main drive pinions and rack gear segments shall conform to the plans.
- (b) An alternative steel casting of equivalent strength, ductility, and hardness may be proposed by the contractor for the rack gear segments. The teeth must be machine cut.
- (c) Erection

The Racks shall be aligned to the following criteria at the same time as the girder/trunnion bearings are being aligned, as they are an integral critical assembly. After the racks are aligned, the pinions are aligned relative to the racks for proper backlash, and tooth mesh contact.

- 1. Rack gear rim face run-out shall be a maximum total of 0.032".
- 2. Rack Gear radial run-out shall be a maximum total of 0.025".
- 3. Rack/ Pinion backlash shall be equal to 0.100" to 0.120".
- 4. Tooth contact area shall be a minimum of 70% of face width and 35% of tooth depth under a no load condition.

16. Span Height Control Drives

- (a) One end of one trunnion in each bascule leaf shall have attached to it a small stub shaft that drives through a right angle reducer (used as speed increaser), the electrical rotary cam limit switch unit, with internal resolver.
- (b) The right angle reducer shall be a precision spiral bevel gearbox, Andantex, Series Z, Size 10, with a 4:1 ratio, but used as a speed

increaser with a 1:4 ratio. The right angle box shall have the low backlash option, with a gear backlash of no more than 3 arc minutes.

17. Main Span Drive

- (a) The main span drive consists of two 50 HP, 1750 RPM gearmotors, with output speeds of 105 RPM. They are connected to the input shafts of the main differential reducer on each leaf.
- (b) The main drive gearmotor shall be an SEW-Eurodrive with a K107 size reducer with a 16.75:1 ratio, and a DV225S4 motor.
- (c) Only one gearmotor at a time drives each leaf.
- (d) All gearmotors shall have the protective canopy option.

18. Emergency Auxiliary Span Drive

- (a) The emergency auxiliary span drive is used when both main drive motors are inoperative. The emergency drive is engaged by a manually operated clutch coupling connected between the auxiliary drive gearmotor and one shaft of a main drive gearmotor, through to one input shaft of the main differential reducer.
- (b) The emergency gearmotor drive consists of a 10 HP motor with a 100.75:1 helical/bevel gear reducer and an output speed of 17 RPM. The gearmotor shall be an SEW-Eurodrive with K107 size reducer, and a DV132M4 motor with rear shaft extension coupled to an enclosed disc brake, spring set, solenoid released.
- (c) The clutch coupling between the gearmotor and the main input shaft shall be a FALK 1030G72 (or approved equal) gear type disconnect coupling with a special hand operated shifter mechanism as shown on the plans. The shifter mechanism shall have a limit switch trip lever; the limit switch disables the main drive motors when the clutch is engaged.
- (d) All auxiliary drive gearmotors shall have the protective canopy option.

19. Center Span Locks and Tail Locks

- (a) General

Provide two center span lock assemblies, and four tail lock assemblies and associated parts as shown on the plans. Power and control wiring are presented in the Electrical specifications.

(b) Center Span Lock Assembly:

The center span lock assembly shall include the electric power cylinder actuator, lockbar, guides and receivers, bushings and shims.

Power Cylinder: The RACO span lock power cylinder shall be a Type N, with spring shock protection, shock absorbing elastomer rings, double wiper seal in front cap, marine epoxy coating, tropical proof corrosion protection, and flexible rod cover (bellows). For the limit switches, refer to the Electrical drawings and specifications for details.

(c) Tail Lock Assembly:

The tail span lock assembly shall include the electric power cylinder actuator, strut, drive linkage, support weldments, bushings and shims.

Power Cylinder: The RACO span lock power cylinder shall be a Type N, with spring shock protection, shock absorbing elastomer rings, double wiper seal in front cap, marine epoxy coating, tropical proof corrosion protection, and flexible rod cover (bellows). For the limit switches, refer to the Electrical drawings and specifications for details.

(d) Erection of Span Lock Assemblies (Center and Tail)

Each Lock assembly, with all guides and electrical connections thereto shall be erected and assembled on the bridge. Full size stainless steel shims shall be used to adjust to correct position, alignment and elevation.

Final adjustment shall be made only after proper shimming of all live load bearings and shall be made at a time when the temperature of the structure is uniform and the wind is calm. Adjust clearances shown on the plans so that no binding occurs when locks are operated under these conditions.

20. Span Centering Device

The span centering device consists of a centering guide, mounted to the West leaf end floorbeam, and the centering socket, mounted to the East leaf end floorbeam, both on the bridge centerline. Mount with 1" A325 structural bolts, washers, and nuts. Supply shims and install the centering device at the conditions shown on the plans.

21. Inspection and Testing

- (a) **Main Power Train: (Main Drive Gear Reducers, Bearings, Shafts, Couplings, etc).** The Engineer shall be given at least two weeks notification prior to all testing.
1. After bolting into place in the shop, each gear reducer shall be spin tested in place for a minimum of two hours (one hour each direction) during which all bearings shall be monitored for noise temperature, and lubrication. Noise level of each reducer shall not exceed 90 dB while operating at maximum speed when the microphone is located 3 feet from the reducer housing. Temperature rise of any component shall not exceed 100 degrees F over ambient.
 2. After completion of the spin test, one output shaft shall be held and input speed reduced to 50 percent of normal to check for proper operation of the differential. This condition shall be held for ten minutes in one direction of rotation and ten minutes in the opposite direction of rotation. The opposite shaft shall then be held, and testing repeated. Noise levels and bearing temperatures shall be recorded. Operational spin testing of the differential shall be performed for both gear reducers.
 3. One of the differential gear reducers shall be chosen by the Engineer for a full load test for either input shaft extension. Blueing shall be applied to all gear sets to demonstrate contact percentage and pattern. The manufacturer shall set up the test rig in such a manner that load sharing of the differential can be verified. Load variation of output shafts shall not exceed 5 percent of each other. Housing deflection under load shall also be measured with dial indicators at each bearing location. Testing duration shall be 30 minutes in each direction of rotation. After load testing, all inspection ports shall be removed and visual inspection of all gear sets shall be performed. Contact patterns from blueing shall be photographed and logged for proper identification. The no-load tests described in paragraphs (1) and (2) above shall be performed again on this reducer.
 4. During final installation, each main drive gear reducer shall be lowered into place over the machinery floor mounting weldment and grillage and adjusted so it is level. The span drive shall be assembled complete as to shafts, couplings, and pinion/bearings/machinery brake sub-assembly and adjusted so the shafts are parallel to the axis of the trunnions and each main pinion meshes correctly with its rack. This adjustment shall be made with stainless steel shims. The floating shafts shall then be uncoupled. Each of the main motors shall be test run in place for 15 minutes in each direction. The reducer housings shall be checked for leaks at bearing covers, seals, inspection

covers, oil drains, bolts and welds. Noise level of each reducer shall not exceed 90 dB while operating at maximum speed when the microphone is located 3 feet from the reducer housing. The main drive motors shall be electrically disconnected and all brakes manually released, and the emergency auxiliary gearmotor drive coupled and test run, as were the main drive motors.

(b) Span Lock Assembly

1. Each span lock assembly shall consist of electric power cylinder with motor brake, stroke limit switches, bellows, trunnion brackets and support base, lockbar, guides and sockets, complete with bearings and shims.
2. After mounting and adjusting, each lock assembly shall be field tested by operating through not less than 3 cycles while the span is in the closed position.
3. Each span lock shall be manually extended and retracted at least three times, with all components assembled in place on the bridge.
4. The span lock assemblies shall also be operated during the electrical sequence testing.

(c) Tail Lock Assembly

1. Each tail lock assembly shall consist of electric power cylinder with motor brake, stroke limit switches, bellows, trunnion brackets and support base, tail lock strut, and complete drive linkage.
2. After mounting and adjusting, each tail lock assembly shall be field tested by operating through not less than 3 cycles while the span is in the closed position.
3. Each tail lock shall be manually extended and retracted at least three times, with all components assembled in place on the bridge.
4. The tail lock assemblies shall also be operated during the electrical sequence testing.

22. Spare Parts

Furnish and store the following spare parts as directed by the Engineer without additional cost.

(a) Drive:

- 2 - Set of Seals and Gaskets for Main Differential reducer.
- 1 - Thruster assembly for the span drive motor brakes.
- 2 - Thruster assembly for the machinery brakes.
- 2 - Pair of brake shoes for the motor brakes.
- 2 - Pair of brake shoes for the machinery brakes.
- 2 - Sets of seals and gaskets for drive motor couplings
- 2 - Sets of seals and gaskets for floating shaft couplings
- 2 - Rack segments, 14 teeth, 20 inv., 13" face, 79.259" P.R.
- 1 - Main pinion (18 teeth, 17.189"P.D.), integral with drive shaft.
- 2 - Pinion Pillow Block split bushings

(b) Span Locks:

- 2 - Complete set of span lock guide and socket bearings and bearing shims. (a set includes all bearings and shims).
- 1 - Complete Span Lock Power Cylinder

(c) Tail Locks:

- 4 - Complete set of tail lock bearings and shims. (a set includes all bearings and shims).
- 2 - Complete Tail Lock Power Cylinder

23. Lubrication

(a) The Contractor shall furnish a lubrication plan for all machinery for approval. The plan shall be developed from recommended practice of the machinery manufacturers. The Contractor shall coordinate the lubrication plans for the various machinery elements and minimize the number of different lubricants. The Contractor shall furnish copies of letters from the various machinery manufacturers endorsing the lubricants which have been finally selected. Lubricants shall be selected for year round exposure at the bridge.

(b) The Contractor shall provide two lever type lubrication guns with three-foot hoses. Fittings shall be located in a protected and convenient position for use and shall be connected to the points requiring lubrication by pipe extensions where necessary. These pipe extensions shall be kept as short as practical and shall be rigidly supported at the fittings and at intermediate points. Pipe shall be 1/4 inch seamless threaded red brass with cast bronze threaded fittings.

Fittings on proprietary parts shall be replaced if necessary with fittings that have been selected as standard for the bridge.

- (c) The Contractor shall furnish a lubrication diagram which shall show all points requiring lubrication, the type of lubricant to be used at each point and the frequency of lubrication. The diagram shall be submitted to the Engineer for approval and the approved diagram shall be mounted in the operator's house with a suitable and approved frame and glass cover.
- (d) A reduced size copy of the Lubrication Diagram shall be included in the Operation and Maintenance Manual.

24. Lubrication Schedule

- (a) The Contractor shall prepare and furnish a lubrication schedule to include the following items, categorized and listed as shown below.
- (b) The following legend shall apply to the lubrication schedule:

DA denotes Direct Application

PLF denotes Pressure Lube Fitting

LPG denotes Low Pressure Grease Gun (for couplings both pipe plugs removed first, replenish grease, then reinstall both pipe plugs).

- (c) Types of Lubricants

Lubricant compounds furnished shall be as recommended and certified by their manufacturer for the use and requirements called for. Lubricants must be recommended for use year round with consideration to ambient temperature ranges that will be experienced by the various components. Synthetic lubricants may be proposed, but must be compatible with all seals and sealing compounds that may be exposed to the lubricant. Contractor shall furnish the Engineer a copy of the certification.

1. Lubricant A - Stiff, high-pressure grease, with best weathering lubricating and corrosion preventive properties.
2. Lubricant B - Best extreme pressure grease for gear and anti-friction bearing lubrication, with some moisture present.
3. Lubricant C - Gear coupling grease approved by coupling manufacturer.

- (d) The foregoing lubricants shall be listed on the lubrication charts herein before specified. All lubricants that will be listed on the lubrication charts shall be approved for use in each proprietary unit by the manufacturer thereof.

ITEM	APPLICATION	PERIOD/ MONTHS	LUBRICANT
General Machinery:			
Span Drive Gearmotors			*
Motor Brakes Couplings	-	*	C
Motor Brake Units	LPG	6	*
Main Drive Shaft Couplings	-	*	C
Machinery Brake Units	LPG	6	*
Pinion Pillow Blocks	-	*	B
Primary Differential Reducers	PLF	4	*
Pinion Shaft Pillow Blocks	-	*	B
Open Gears (Racks/Pinions)	PLF	1	A
Auxiliary Drive Gearmotor (when in use)	DA	1	*
Trunnion Bearings	-	*	B
Rotary Cam Limit Switch Bearings	PLF	3	B
Span Lock Assembly (Two Total):			
Span Lock Drive Actuator Motor	-	*	*
Gear Reducer	-	*	*
Screw/Nut Assembly	-	*	*
Lockbar Support Bearings	-	*	*
Tail Lock Assembly (Four Total):			
Tail Lock Drive Actuator Motor	-	*	*
Gear Reducer	-	*	*
Screw/Nut Assembly	-	*	*

* denotes frequency and type of lubrication, as recommended by the manufacturer.
Lube chart to establish requirements; categorized and listed as shown.

25. Tools and Equipment

- (a) The bridge shall be equipped with the following tools and lubrication equipment:

- 2 each - Box and open-end combination wrenches made of high-grade, drop-forged steel, with chrome-plating over nickel finish, to fit bolt heads, nuts, and cap screws from 1/4 to 1-1/4 inches, inclusive.
- 2 each - Single-end, angle wrenches of high-grade, drop-forged steel to fit all bolt heads and nuts larger than 1-1/4-inch size actually used in the job.
- 1 set - Socket wrenches, as required, to supplement the wrenches in Items (a) and (b) for dismantling flexible couplings.
- 1 each - 12-inch adjustable wrench.
- 1 set - Alloy-steel hex wrenches for all socket-head screws.
- 1 each - 8-inch and 10-inch screwdrivers with solid, hardened steel square shanks, and insulated composition handles.
- 1 each - 2-pound ball-peen hammer.
- 2 each - Hand lubrication guns, screw type, 12-ounce capacity, for each size lube fitting used.
- 1 each - Load pump for 25-pound capacity pail for each type gun furnished.
- 1 each - Grease transfer pump, complete with hose and fittings for 120-pound drum.
- 1 each - Of any other size wrenches and special tools for lubrication gun as required by the machinery manufacturer.
- (b) The set of tools, plus grease guns, shall be mounted in a sufficiently sized 1/8-inch thick steel cabinet provided by the Contractor with hinged doors and locks. The cabinet shall be welded steel construction, with all outside welds continuous and ground smooth. Suitable clips shall be installed in the cabinet for holding each tool in place. The space of each wrench shall be labeled with the wrench opening, and the spaces for other tools shall be labeled with the tool name. The Contractor shall also furnish a steel cabinet similar to the tool cabinet. The Contractor shall also furnish a suitable work bench, machinist's vise, and two portable steel tool boxes. The tool boxes shall be approximately 8-1/2" by 9" by 30".

PART 3 QUALITY CONTROL AND ASSURANCE PROGRAM

3.1 QUALITY CONTROL

- (A) The Contractor shall maintain and be responsible for the Quality Control of the installation of the bridge operating machinery. The Contractor's Quality Control Manager shall monitor the installation of all mechanical components included in this section, and insure that all work is performed in accordance with the Contract Documents, Specifications, manufacturer's installation procedures and all applicable Codes and Standards.
- (B) The Contractor's Quality Control Manager shall maintain documentation of all required mechanical testing and shall turn them over to the Engineer in a timely manner.
- (C) The Contractor's Quality Control program shall be responsible for notifying the Engineer immediately for clarification whenever any portion of the work is not clearly or accurately defined.
- (D) Warranty. The Contractor shall remedy defects due to workmanship, erection, materials or design for a period of one year after final tests and acceptance have been made, at his own expense. The Contractor shall furnish a satisfactory guarantee to ensure correction of defects. If necessary, such defects may be corrected by others at expense to the Contractor.

3.2 QUALITY ASSURANCE

- (A) The Engineer shall, at his discretion and as he deems necessary, inspect and verify the procedures and operations being performed during the installation of the bridge operating machinery.
 - 1. Inspection. Materials and fabrication procedures are subject to inspection and testing in the mill, shop and field by the Engineer. Such inspections and tests will not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
 - 2. Design of Items and Connections. All details shown on the Contract Drawings are typical and apply to similar conditions unless otherwise indicated. All dimensions and details shall be verified at the site before proceeding with any work and to avoid causing subsequent delay in work.
- (B) The Engineer shall be responsible for reviewing all QC records and test reports submitted by the Contractor's Quality Control Manager.
 - 1. Certified Test Reports. As used herein, certified test reports refer to reports of tests conducted on previously manufactured materials or equipment identical to that proposed for use.

2. **Factory Tests.** As used herein, factory tests refer to tests required to be performed on the actual materials or equipment proposed for use. Results of the tests shall be submitted in accordance with the provisions of this Contract for laboratory test results.

PART 4 EXECUTION

4.1 SHOP ASSEMBLY AND OPERATION

- (A) Machinery components mounted on common bedplate shall be shop assembled with turned bolts to verify their correct fit prior to shipment. Any components requiring selective assembly shall be match-marked for future assembly.
- (B) After the span operating machinery (drive motors, motor brakes, couplings) has been sub-assembled in the shop, the entire gear train shall be driven under power forward and backward sufficiently to demonstrate that all shafts run freely. Parts shall have the minimum amount of play consistent with their free operation where not otherwise specified.
- (C) The various parts of units or groups, such as gear reducers, shaft couplings, and bearings, before leaving the shop shall be marked according to mating, location and correct relation to facilitate reassembling at the bridge site. Stamp markings shall be made in areas of the part or assembly that are not subjected to significant stress during operation.

4.2 DELIVERY, STORAGE AND HANDLING

- (A) All components and materials shall be delivered to the site in accordance with the approved schedule of work. Any special provisions used for material handling shall be provided by the Contractor.
- (B) Components and materials shall be properly packaged and protected from initial shipment until the time of installation.
 1. Assembled units shall be mounted on skids or otherwise crated for protection during shipment and storage.
 2. Finished and unpainted metal surfaces that would be damaged by corrosion, shall be coated with a .030" minimum film thickness, as soon as practicable after finishing, of No-Ox-Id, A-Special, as manufactured by San-Chem Company, Chicago, Illinois, or approved equal. This coating shall be removed from all surfaces prior to lubrication for operation and from all surfaces prior to painting after erection. If the anti-rust coating on any part

becomes compromised prior to part installation, the coating shall be restored immediately.

3. Shaft journals that are shipped disassembled from their bearings shall be protected during shipment and before erection by a packing of oil-soaked waste secured in place by burlap and covered with heavy metal thimbles or heavy timber lagging securely attached; an alternate method may be submitted for approval. Every precaution shall be taken to ensure that the bearing surfaces will not be damaged and that all parts shall arrive at their destination in satisfactory condition.
- (C) Material storage on site shall afford easy access for inspection and identification, protection from the ground and prevent distortion or damage.

4.3 ERECTION

- (A) Erection work shall not commence until the required items have been completed and approved for installation, and until preparations by others where required have been satisfactorily completed.
- (B) The Contractor shall provide personnel and supervising engineers familiar and experienced in the installation of movable bridge machinery, especially for bascule spans. The Contractor shall provide all the precision equipment that may be required for the proper and accurate installation of the machinery.
- (C) Prior to erection, all finished surfaces, which were coated by a rust-inhibiting coating, shall have the coating removed with gasoline, benzene, or other approved solvent. While machinery parts are being erected, and work is interrupted, they shall be covered by a sound tarpaulin or other durable waterproof covering.
- (D) The machinery: motors, reducers, brakes, bolsters, shafting, couplings, ancillary electrical equipment connected to the operating machinery, racks, pinions, trunnions, trunnion bearings, bearing bolsters, span locks, span centering device, and the like shall be erected and adjusted by competent mechanics and millwrights skilled in the type of work involved. Representatives of the machinery manufacturers shall be present during final assembly. They shall be provided with all necessary precision measuring and leveling instruments as may be required. The machinery shall be erected with exactness so the various parts are truly aligned in their proper positions and, when entirely assembled, will operate smoothly without binding or undue looseness of the components.
- (E) All parts of the machinery shall be erected in accordance with erection marks and match-marks. When the final position of the machinery will change upon application of the full dead load, the final adjustments shall be made after the dead load is fully applied. Before final drilling or reaming, all parts shall be adjusted to

exact alignment by means of shims furnished for each part. After final alignment and bolting, all components shall operate smoothly.

- (F) Bolt holes in structural steel for connecting machinery with turned bolts shall, in general, be drilled from the solid after final alignment of the machinery. Sufficient erection holes, sub-drilled 1/8 to 1/4 of an inch undersize for temporary bolts, may be used for erection and alignment of the machinery. When the machinery is aligned in its final position, full-size holes for the permanent turned bolts shall be sub-drilled and reamed; full-size bolts installed; and the temporary bolts removed.
- (G) ASTM A449 bolts shall be torqued to the same tension required for ASTM A325 bolts.
- (H) Torques for other grades of bolts shall be proportioned to their strength and shall be indicated on the erection drawings.
- (I) The trunnion bearings shall be carefully located and adjusted so that when the full dead load of the bascule span and counterweights is carried by the trunnions, the axes of the two trunnions of each leaf will be as near to a straight line as possible, with a tolerance of 1/16" total offset in any direction. Final adjustment of the rack/pinion gears mesh shall occur only after the trunnion bearings are under the full dead load of the bascule span and counterweights.
- (J) Throughout the installation, bolts and nuts shall be adjusted or tightened only with wrenches that fit; tightening with chisels and hammers will not be permitted.
- (K) Installation and alignment of all mechanically connected machinery and electrical equipment shall be conducted under supervision of the machinery manufacturer's field engineer.
- (L) The machinery and all machine-like elements or parts, especially all trunnion/girder assemblies and their bearings, shall be assembled, erected, aligned, and adjusted at the bridge site under the direct and continuous supervision of the Engineer, to whom the Contractor shall afford every opportunity and facility to satisfy himself that the work is being done in accordance with the plans, specifications, and acceptable construction practices.
- (M) Alignment of all machinery shall be rechecked after all connections and drives have been installed and in operation for a minimum of 10 opening/closings.

4.4 PAINTING

- (A) Cleaning and painting of machinery metalwork surfaces shall conform to the NCDOT standard requirements for structural painting and shall be indicated on the shop drawings. Factory painted machinery items shall be hand tool or solvent

cleaned and overcoated with the top coat of the specified paint system in the appropriate color as indicated in this section for movable and stationary components.

- (B) Machinery component surfaces to be painted shall be given one prime coat in the shop. A second touch-up prime coat shall be field applied to damaged or unprimed metalwork and a full intermediate coat applied after machinery and equipment have been installed. The final high gloss top coat shall be applied after completion of operating tests. Color for the top coat will be Federal Safety Orange for all moving parts including shafts, couplings, sides of pinions and racks, gears, and brake wheels. Bearing and lubricated surfaces shall not be painted. Color for the top coat of stationary parts shall be Federal Safety Green.
- (C) Before application of paint in the shop, surfaces which require painting shall be cleaned of all chips, burrs, dirt, rust, mill scale, sand, grease, and other extraneous materials by employing methods such as chipping, grinding, wire brushing, solvents, followed by the required abrasive blast cleaning and residual removal by compressed air. Finished machined surfaces not to be painted shall be masked or shielded from abrasive blasting operations. After cleaning, surfaces requiring paint shall be painted with one prime coat. Bearing or sliding surfaces that are not painted will be coated with temporary protective materials as approved by the Engineer. Nameplates shall be clean and free of paint.
- (D) After the machinery items have been installed in final position on the bridge, all surfaces which require paint shall be cleaned of grease, oil, and loose materials by the use of solvents and compressed air, and all unprimed or damaged shop prime coated surfaces shall be repaired with the touch-up primer followed by a full intermediate coat. The Contractor shall take special care to avoid painting of machinery bearing and sliding surfaces and to mask and protect from paint these surfaces and all nameplates, legend plates, and escutcheons mounted on machinery.
- (E) After completion of the operating tests and acceptance of the machinery, all oil, grease, dirt, and other foreign matter shall again be cleaned from exposed machinery surfaces. The exposed surfaces shall then be given a third field coat, the top coat, which shall color-code the machinery to identify fixed and moving parts as indicated previously and as shown on the shop drawings.
- (F) Should the top coat of paint submitted and approved for use on the structural metalwork not be available in the safety colors required for the machinery metalwork, a substitute top coat meeting the performance and color requirements of the top coat specified and compatible with the specified intermediate coat shall be submitted to the Engineer for approval. The Contractor shall place a cautionary sign in the Operator's House and at the entrance to the machinery area of each leaf to explain the color code. Details of the sign including text, dimensions, mounting locations, and materials shall be submitted to the Engineer for approval.

4.5 LUBRICATION

- (A) During installation, the Contractor shall lubricate all rotating and sliding parts of the machinery, and fill all gear reducers, pillow block housings and flexible couplings with lubricants indicated on the approved charts. All lubricants listed on the lubrication charts shall be approved for use in each proprietary unit by the manufacturer thereof. The Contractor shall furnish an additional supply for future maintenance use to include 25 pounds of each type of grease and 15 gallons of each type of oil.

- (B) After erection is complete, the Contractor shall make a thorough inspection to ensure that all gears are clean and free of obstruction, that all parts are aligned as closely as practicable without actual operation, and that all bolts are properly tightened. All gear housings shall be filled to the proper level, and all rotating and sliding parts shall be supplied with lubricants. All lubrication requirements listed in the lubrication schedule herein shall be performed by the Contractor until the final acceptance by the Owner.

4.6 CONTRACTOR SUPERVISED BASCULE SPAN OPERATION

Provide a minimum of two men to supervise the operation of the bridge for a period of 14 calendar days after the road traffic is on the new bascule span; and for an additional 14-day period, provide one man. These men shall be able to operate the bridge, to supervise its operation, and to make any adjustments or corrections that may be required in the mechanical or electrical equipment of the bridge. They shall instruct and qualify the employees of NCDOT in the operation of the bridge. Any adjustments or corrections required during the two 14-day periods shall be at no additional cost.

PART 5 MEASUREMENT AND PAYMENT

Mechanical work required by this section shall be measured as a single item, complete, installed and tested. Payment shall be on the basis of a single lump sum item.

Pay Item	Pay Unit
New Eastbound Bridge-Mechanical Work	Lump Sum

NEW EASTBOUND BRIDGE SPAN BALANCE

1.0 SCOPE

This section is intended to present the requirements associated with span balance during all phases of new construction, and includes strain gage balance testing and analysis, balance monitoring throughout construction, and all required weight changes to maintain the balance requirements provided herein.

Strain gages shall be installed and data recorded to evaluate the balance condition of each leaf after all construction work on the moveable leaves has been completed. The Contractor shall, at the direction of the Engineer, make necessary weight adjustments, based upon the analysis of the strain gage tests. A final strain gage retest shall be performed after the adjustments are complete to validate the final balance condition of the bridge.

2.0 BASCULE LEAF BALANCE

(A) Preliminary Span Balance

The Contractor is responsible for determining the preliminary balance conditions of the moveable leaves by utilizing hydraulic jacks mounted adjacent to the live load bearings on each leaf. The Contractor shall submit his methods and calculations for mounting the hydraulic jacks to the Engineer for approval. Calculations shall be signed and sealed by a Professional Engineer. Preliminary balancing on each leaf shall be performed by the Contractor after all construction is completed, and adjustments to the span and/or counterweight have been made.

(B) Strain Gage Balancing

The Contractor is responsible for determining the final balance conditions of the moveable leaves by utilizing the strain gage procedure described below. Strain gage balancing on each leaf shall be performed by the Contractor after all construction is completed, and after preliminary balance adjustments to the span and/or counterweight have been made.

Two bi-axial strain gage rosettes shall be mounted on each output shaft (in between the reducer output and the main pinion), configured in such a way as to cancel the effects of bending, so that only torsional strain in each shaft is being measured. Strain in each shaft shall be continuously measured by a data acquisition system. The angle of opening of the bridge shall be simultaneously recorded by the same data acquisition system as the shaft strain.

Prior to performing strain gage measurements, the Contractor shall submit full documentation of the proposed procedure, including instrumentation equipment, strain gage mounting and wiring arrangements, and specific formulas and equations to be utilized for data analysis.

Prior to recording strain, the strain readings shall be zeroed and all static torsional loading shall be relieved from the machinery: all brakes shall be released, and all pinions adjusted such that pinion and rack teeth are not in contact. Feeler gages shall be utilized at each pinion to confirm that teeth are not in contact.

Strain gage measurements shall be taken only on a dry, calm day, with wind loads less than 5 mph, when there is no extraneous equipment, debris, rainwater, ice, snow, or other material on the bridge that would affect the balance of the spans.

Each leaf shall be tested through at least three (3) complete operational cycles and a permanent record of each test shall be maintained.

The Contractor shall submit a report of the results of the balance determination. From the strain data, shaft torque and bridge unbalance, as seen at the tip of the leaves, shall be computed and plotted against the angle of opening from full closed to full open, and from full open to full closed. A plot of raw data strain against the angle of opening shall also be included. Also included in the results presentation shall be a discussion on the peak operating torques as a percentage of the full load motor torque (when they occur and their magnitude) and system friction.

Initial balancing shall establish the existing balance baseline for use in the balance spreadsheet. If the results of the initial balancing determine that the bridge balance is outside of the acceptable balance condition, the Contractor shall coordinate with the Engineer the means and methods to bring the bridge into an acceptable balance. Final balancing shall be performed to verify that an acceptable final balance has been obtained after the adjustments.

If the final balancing results indicate that an acceptable final balance condition has not been obtained after the adjustments have been made, the Contractor shall make additional adjustments and repeat the balance testing as required until the desired balance conditions have been achieved.

Additional balance weights shall be furnished by the Contractor as required.

The testing and all balance calculations shall be performed by a Professional Engineer. The Contractor shall provide evidence of successful strain gage balancing experience on a minimum of three (3) bascule bridges within the previous five years. A complete test procedure,

along with the resume of the Engineer conducting the tests, shall be submitted for approval prior to the initial balancing test.

The test procedure shall include the following:

- Test method
- List of equipment
- Sample calculations
- Report format

After the balance tests have been completed, the Contractor shall submit a formal report signed and sealed by the Professional Engineer who conducted the tests. The report shall include the following:

- Introduction
- Test procedure and Equipment
- Method of analyzing recorded data
- Presentation of results
- Conclusions
- Calculations
- Graphical representation of Span Balance vs. Opening Angle

(C) Balance Requirements

The balance for each leaf shall be adjusted to meet the following requirements:

1. During Construction, Bridge Operation Not Permitted. Bridge is in the Closed Position, with Span Locks Driven.

The movable leaf must be span heavy, with a positive toe reaction between 0 lbs and 10,000 lbs with the bridge in the closed position. The center of gravity must be between -80° and $+80^{\circ}$ with the leaf in the closed position.

2. During Construction, Bridge Operation Permitted.

The movable leaf must be span heavy in the closed position, with a positive toe reaction between 1,000 lbs and 5,000 lbs with the bridge in the closed position. The center of gravity must be located between -80° and $+80^{\circ}$ with the span in the closed position.

3. Final Balance Condition of Bridge Following Construction.

The movable leaf must be span heavy in the closed position, with a positive toe reaction between 1,500 lbs and 3,700 lbs with the bridge in the closed position. The center of gravity must be located between +20° and +55° with the span in the closed position.

NOTE: The center of gravity location is measured from the horizontal on the channel side of the trunnion (i.e. an angle of +20° indicates the center of gravity is located on the channel side of the trunnion at an angle of 20° above the horizontal).

3.0 MEASUREMENT AND PAYMENT

Work required by this section will not be separately measured. There will be no direct payment for this span balance section, but the costs shall be included in the lump sum price bid for the New Eastbound Bridge Mechanical Work.

NEW EASTBOUND BRIDGE MECHANICAL OPERATION AND MAINTENANCE MANUAL

1.0 GENERAL

Provide preliminary and final versions of the Mechanical Operation and Maintenance manual for the mechanical drive and support system, including all span locks, equipment, and materials.

2.0 MATERIALS

(A) Manual

Binder shall be hardback vinyl three ring loose leaf-type of one solid color. Binder spine and front shall display labels containing the name of the bridge location, the name of the contractor and dates of the work.

The binder holes shall be reinforced for all contents. The paper and ink shall resist smearing, fading and deterioration from age.

(B) Chapters

The volume shall have a format and be divided into chapters as follows:

1. Chapter 1 will be designated for general information and safety precautions. Information from the department's safety manual shall be included as applicable.
2. Chapter 2 shall contain the operational description of the particular system or piece of equipment or material where applicable.
3. Chapter 3 shall cover the functional description, including: block diagrams; schematic layout of the entire system; description of subsystem; functional relationship between systems and subsystems.
4. Chapter 4 shall cover scheduled maintenance, where applicable. This chapter shall provide all preventive maintenance procedures to the lowest repairable unit level and any checks, tests and measurements required on a periodic routine basis. Preventive maintenance indexes (PMI's) shall be provided in this section and shall be organized in tabular format to provide quick, easy reference to each preventive maintenance action performed according to the prescribed maintenance interval, as well as applicable preventive maintenance procedures contained within the manual.
5. Chapter 5 shall consist of troubleshooting diagrams (fault isolation trees) to be used by maintenance personnel for isolating fault to the lowest repairable limit level.

6. Chapter 6 shall cover all corrective maintenance procedures that are required to repair a particular system, piece of equipment or material back into satisfactory operating condition. This chapter shall provide step-by-step procedures for the replacement of defective parts. Reference shall be made according to the applicable test procedures established in Chapter 4. Warnings or precautions to be observed during maintenance shall be listed.
7. Chapter 7 shall provide step-by-step installation procedures to the lowest repairable limit level for a particular system, piece of equipment, or material.
8. Chapter 8 shall consist of complete parts lists to the lowest repairable limit level for each system, piece of equipment, or material. Parts lists shall include exploded views of assemblies as required. The local representative of the parts supplier shall be listed.
9. Chapter 9 shall include the duration and contents of all guarantees and warranties.
10. Chapter 10 shall include half-size prints of approved shop drawings. The prints shall be folded to fit into the manual.

The vendor shall recommend, in writing, for the Engineer's approval, all lowest repairable units for each system, piece of equipment, or material. A lowest repairable unit shall be defined as that equipment which cannot be economically repaired, or which requires skills and equipment beyond those available by the department's maintenance personnel. The lowest repairable unit concept shall be used to prepare all written maintenance, repair, inspection, testing, replacement, and installation procedures for the mechanical maintenance manual covered herein.

Parts lists shall be in tabular form and shall include each part name, description, name of manufacturer's order/part number and shop drawings reference. Parts lists shall be supported by adequately labeled exploded views or pictorial views where applicable. All special tools, jigs, fixtures, test and calibration equipment used in any maintenance, inspection repair or adjustments shall be included.

With the exception of shop drawings, all illustrations (block diagrams, schematic diagrams, exploded views, pictorial views printed circuit board layouts, etc.) shall be single line artwork. All lettering on illustrations shall be by lettering guide or equivalent to illustrate call-outs. All lettering shall be clear and legible in final form.

All written test and descriptive material shall be written to a 9th grade level.

Paragraph numbering will be sequential and indicate chapter location. Roman numerals shall not be used.

Front matter shall include a cover page with descriptive title, project, contractor and

engineer. A table of contents shall be provided to indicate each chapter and paragraph subtitles, numbering and page locations.

Safety warnings or cautions shall be visibly highlighted within each maintenance procedure. Use of such highlights shall be limited only to critical items and shall not be used in excessive manner which would reduce their effectiveness.

(C) Content Requirements

Vendors and suppliers listing to include names, addresses and telephone numbers.

Neatly typewritten index near the front of the manual, furnished immediate information as to location in the manual of all emergency data regarding the installation.

Complete instructions regarding operating, lubricating, adjusting and maintenance of all equipment involved.

Where the contents of the manuals include manufacturer's catalog pages, clearly indicate the precise items included in this installation and delete all manufacturer's data with which this installation is not concerned.

All material within the manuals shall be new. Copies used for prior submittals or used in construction of the project are not acceptable.

Manuals shall have index tabs for fast and easy reference to equipment and material. Tabs shall index each piece of equipment and systems.

(D) Construction

Make a preliminary manual submittal of two copies to the Engineer for review and approval; make a submittal of three copies of the final manual in to the Engineer.

Submittal of preliminary and final manual editions shall be furnished to the Engineer according to the approved official progress schedule.

Preliminary manual editions shall present all technical material for the mechanical volume to the greatest extent possible with respect to text, tabular matter, and illustrations. Preliminary manual editions shall be single column. Double-spaced, and typewritten. Illustrations shall preferably consist of line drawings. (Sketches or photographs may be used if final line drawings are unavailable at the time of submittal.) All applicable shop drawings shall be included.

Preliminary manual editions shall be as technically complete as the final manual edition. All illustrations shall be in final form. Reduced size shop drawings, as specified in paragraph J of "Format", shall be included.

Final manual editions shall be technically accurate and complete and shall represent the "as-built" system, piece of equipment, or material given final acceptance by the Engineer. All illustrations, text, and tabular material shall be in final form; all shop drawings, as specified in paragraph J of "Format", shall be included.

(E) Recommended Format

Information shall be furnished for the following items of mechanical machinery.

Mechanical Equipment:

1. Main differential gear reducer.
2. Brakes: Motor and Machinery.
3. Gearmotors- Main and Auxiliary
4. Center span locks.
5. Tail locks.
6. Flexible couplings and disconnect couplings.
7. Bearings and bushings (trunnion and pinion).
8. Shafts.
9. Open gearing: pinions and rack segments.
10. Seals
11. Standard operating instructions and emergency operation instructions.
(Two separate sets of directions.)
12. Lubrication schedule and diagram.
13. Reduced size "as-built" contract drawings.

3.0 MEASUREMENT AND PAYMENT

The Mechanical Operation and Maintenance manual will not be separately measured.

There will be no direct payment for the Mechanical Operation and Maintenance manual, but their costs shall be included in the lump sum prices bid for the various items requiring operation and maintenance manuals. The bridge shall not be opened to traffic (roadway) until this manual has been provided and acceptable to the Engineer.

REHABILITATION OF WESTBOUND BRIDGE MECHANICAL WORK

1.0 SCOPE

This section covers all products, labor, services, incidentals, and related work necessary to furnish, install, test, and put into permanent service all miscellaneous mechanical work as shown on the plans and described herein. The installation and adjustment of all machinery shall be by millwrights experienced in this class of work.

2.0 REFERENCES

The issue date of references included in these project specifications and Contract plans need not be more current than provided by the latest Change Notice to this specification. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The latest revisions only shall be used for all references.

American Association of State Highway and Transportation Officials (AASHTO) LRFD Movable Highway Bridge Design Specifications, 2nd Edition, 2007 and Later Interim Revisions

American Gear Manufacturers Association (AGMA), latest version of all applicable standards.

American National Standards Institute (ANSI), latest version of all applicable standards.

American Society for Testing and Materials (ASTM), latest version of all applicable standards.

American Welding Society (AWS), Structural Welding Code, D1.1-2010.

3.0 QUALITY ASSURANCE

Inspection: Materials and fabrication procedures are subject to inspection and testing in the mill, shop and field by the Engineer. Such inspections and tests, if performed, will not relieve the Contractor of the responsibility for providing materials and fabrication procedures in compliance with specified requirements.

- (A) **Design of Items and Connections:** All details shown on the Contract Drawings are typical and apply to similar conditions unless otherwise indicated. Dimensions and details in the Contract Plans are for Bid-Purposes only and shall be verified via field measurements and erection-design layouts by the Contractor before proceeding with any work, obtaining final approval of any Shop Drawings by the Engineer, and to avoid causing subsequent delay in work.

- (B) The Engineer shall be notified immediately for clarification whenever any portion of the work appears unclear or not accurately defined.
- (C) **Certified Test Reports:** As used herein, certified test reports refer to reports of tests conducted on previously manufactured materials or equipment which are purported to be identical to that proposed for this application.
- (D) **Mill/Factory Tests:** As used herein, mill or factory tests refer to tests required to be performed on the actual materials or equipment proposed for this application. Results of the tests shall be submitted in accordance with the provisions of this Contract.

4.0 SUBMITTALS

- (A) In addition to the requirements of Section 1 – Working Drawings and Submittals, the Contractor shall submit:
 1. Mill test reports or certified test reports for all metals used
 2. A complete list of all proposed new or rehabilitated machinery items which require lubrication. The list shall be maintained throughout construction and shall contain the type of lubricant used and the date it was installed by the Contractor. The list shall be given to the Engineer prior to start up and testing of the respective machinery.

5.0 GENERAL MATERIALS, BRACKETS, AND SUPPORTS

- (A) Unless specifically indicated otherwise, plates, shapes (angles, channels, etc.), fabricated brackets, and similar items shall ASTM A588, HSLA steel, or approved equivalent.
- (B) Unless specifically indicated otherwise, all stainless steel shall be "Marine Grade", Type 316. If the Contractor can demonstrate to the satisfaction of the Engineer that Marine Grade stainless steel is not available for the item in question, a lesser grade, such as Type 302/304, will be considered for approval.
- (C) Fabricated items which are constructed by welding shall be thermally stress relieved after welding and before any machining or finishing. All welds shall be continuous, unless otherwise specified. All web and stiffener thickness edges shall be welded, either fillet or bevel if flush with adjoining plate. Bevel flush welds shall be ground smooth.
- (D) Fabricated steel items which are to be galvanized shall be hot-dip galvanized after fabrication. Hot-dip galvanizing shall be in accordance with the American Galvanizers Association Suggested Specification for Hot-Dip Galvanizing.
- (E) Welding shall be in accordance with American Welding Society standards appropriate for the material(s) and final product in question.

- (F) Isolate galvanized items from unpainted and/or "weathering" steel with neoprene shims.

6.0 MANUFACTURED ITEMS

- (A) The Contractor shall submit shop drawings to the Engineer for approval. These shall include complete details, specification of materials, schedules for fabrication and shop assembly, procedures and diagrams showing sequence and details for erection. The Contractor is responsible for providing all field measurements and erection layouts necessary to fully define the details of all fabricated components. Reformatted contract plans, without complete manufacturing and erection information as set forth herein, shall not be considered satisfactory shop drawings.
- (B) Shop drawings with erection-dependent data, required from the Contractor, may be conditionally approved by the Engineer for material allocation or procurement. The Contractor shall be fully responsible for providing final details (e.g. exact shaft lengths) to the supplier for fabrication.
- (C) Variations between the conditionally approved shop drawings and installed components shall be recorded and submitted on the As-Built Drawings.
- (D) Shop drawings for manufactured detail parts shall be given a suitable title to describe the parts detailed thereon. These drawings shall be so complete that parts may be duplicated without reference to patterns, other drawings, or individual shop practice. Each drawing shall be identified by the complete project name and number, and shall include:
 1. Dimensions, call-outs and notes to completely define the final form, fit, function, manufacturing process and allowable deviations for each feature of each item.
 2. Material specifications for each item including heat treatment, specific hardness and/or mechanical properties requirements when mandated.
 3. The surface finish of machined surfaces and tolerance dimensions at all locations for which a specific fit is required. A general tolerance block conforming to the Contract Plans shall be used to define the tolerances of all other dimensions. Fits and finishes shall be the more rigorous of AASHTO or manufacturer specifications.
 4. Quantities of all details required for their associated assemblies and quantities of complete assemblies for the entire bridge.

5. Component weights for purchased and manufactured items shall be shown on the same shop drawings as the component details to facilitate material handling planning.

7.0 PURCHASED ITEMS AND ASSEMBLIES

- (A) Shop drawings for purchased components shall be given a suitable title to describe the parts detailed thereon and shall include:
 1. Complete data on the design and construction of all detail components furnished as part of the machinery under this Contract as presented herein.
 2. All proprietary items shall be shown in outline on shop drawings and shall include:
 - (a) Complete assembly diagrams shall be provided for proprietary components that show each part contained within the item and its corresponding manufacturer's part number. The diagrams shall be sufficient to enable complete disassembly and re-assembly of the subject component and enable the definition and procurement of proper spare/replacement parts.
 - (b) In the event that any part is modified in any manner from the way it is described or delivered by its original manufacturer, the Contractor shall deliver a drawing which details each modification, and the part shall be assigned a unique part number to assure procurement of proper spare/replacement parts.
 - (c) Certified external dimensions and clearances affecting interfaces or installations.
 - (d) Gross weight.
 - (e) Capacity and normal operating ratings.
 - (f) Method, recommended type and quantity of lubrication, including location and type of fittings and provisions for adding, draining and checking the level of each lubricant employed.
 - (g) Inspection openings, seals, and vents.
 3. Complete shop bills of materials shall be included for all machinery parts. If the bills are not shown on the shop drawings, prints of the bills shall be furnished for approval in the same manner as specified for the drawings.

4. Complete assembly and erection drawings shall be furnished. These drawings shall provide identification, and essential locating dimensions for each part or assembly with respect to the bridge or foundation.
- (B) Shop drawings, which have not been approved or require correction, shall be resubmitted until they are approved by the Engineer. This approval-procedure shall not be considered a cause for delay. The Contractor shall bear all costs or damages which may result from the ordering or fabrication of any materials prior to the acceptance of the shop drawings. As a means of expediting delivery prior to acceptance of the shop drawings, the Contractor may request in writing from the Engineer, approval to order raw materials of the correct type for later fabrication from accepted shop drawings. Such approval by the Engineer shall be in writing. After acceptance of the shop drawings, the Contractor shall supply the Engineer with additional copies of the accepted drawings as may be required.
- (C) Material certifications and component test reports shall be submitted for approval as required by the standards.

8.0 MATERIALS

- (A) Materials and components shall conform to the drawings and referenced standards.
- (B) Hardness shall be tested and reported for details with required hardness values.
- (C) No item shall be fabricated without sufficient advance notice given to the Engineer to permit inspection.
- (D) The Contractor shall furnish all facilities and provide for the free access at the plant or shop for the inspection of material and workmanship.
- (E) Acceptance of a material or item shall not preclude subsequent rejection if defects are found later.
- (F) The Contractor shall furnish the Engineer with of copies of purchase orders as requested.
- (G) Unless otherwise provided, the Contractor shall furnish without charge test specimens required herein, all labor, testing machines, tools and equipment necessary to prepare the specimens and to make the physical tests and analyses. Two copies of test reports and chemical analyses shall be furnished to the Engineer.

9.0 MANUFACTURER'S RECOMMENDATIONS

When installation procedures for an item or component are required to be in accordance with the recommendation of the manufacturer, printed copies of the recommendations

shall be furnished to the Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

10.0 STANDARD PRODUCTS

- (A) Materials and equipment shall essentially be standard, current production, cataloged products of established manufacturers, and have at least two years of satisfactory commercial or industrial use prior to bid opening.
- (B) Where two units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the products of the same manufacturer.
- (C) Each major assembled component shall have a conspicuous, durable, permanently affixed nameplate that includes at least the following information: the manufacturer's name, address, the component model number, serial number, rated capacity and pertinent factory setting(s). The nameplate of the distributing agent will not be acceptable.
- (D) Copies of nameplates and/or equipment tags shall be furnished as part of the shop drawing and included in the Operation and Maintenance Manual for future reference on all machinery.
- (E) Materials of equal or greater strength and corrosion resistance than shown on the design drawings can be proposed and are subject to approval by the Engineer.
- (F) Electrodes for welding shall comply with AWS Code.
- (G) Heavy hexagonal head structural bolts, heavy hexagonal nuts, and hardened washers shall conform to ASTM A325, A563 Grade C, and F436, respectively. ASTM A307 shall not be used.
- (H) Alloy steel hex socket head cap screws and hex socket head shoulder screws shall comply with ASTM A574. Stainless Steel hex socket head cap screws shall be Type 316, with a minimum tensile strength of 80,000 psi, and shall meet or exceed ASTM F837, Alloy Group 1, Condition CW, unless otherwise specified. Stainless Steel hex socket flat countersunk head screws shall be Type 316, with a minimum tensile strength of 80,000 psi, and shall meet or exceed ASTM F879, Alloy Group 1, Condition CW, unless otherwise specified. Dimensions shall conform to ANSI B18.3.
- (I) Stainless steel for other fasteners, threaded rods, pins, and dowels, where specified, shall be Type 316 Stainless Steel, with a minimum tensile strength of 85,000 psi and shall meet or exceed ASTM F593, Alloy Group 2, Condition CW, unless otherwise specified. Stainless steel for hex nuts shall be Type 316, with a

minimum proof strength of 85,000 psi and shall meet or exceed ASTM F594, Alloy Group 2, Condition CW, unless otherwise specified. Stainless Steel washers where specified shall be Type 316. Stainless steel shim material shall be ASTM A240 or A666, Type 316.

- (J) Equipment covers and guards, unless specified otherwise, shall be a minimum 14 gauge stainless steel conforming to ASTM A240, Type 316, welded at corners, adequately stiffened and held rigidly in place. Covers and guards shall be provided wherever necessary for safety of maintenance or other personnel and to protect components from the elements.
- (K) Unspecified steel plate for details and weldments shall conform to ASTM A588, HSLA steel, except for minor weldments, brackets, and pedestals for mounting electrical components, which may be ASTM A36 structural steel.

11.0 DETAILS AND WORKMANSHIP

- (A) The machinery shall be finished, assembled, and adjusted in an approved manner using best shop practice. The limits of accuracy which are to be observed in machining all parts, and the allowances for all metal fits shall be placed on the Shop Drawings.
- (B) Where surface finishes are indicated, the symbols used shall conform to ANSI B46.1, "Surface Texture". Roughness specified is the maximum value, and any smoother finish will be satisfactory. Compliance with specified surface will be determined by trained sense of feel and by visual inspection of the work compared to "Standard Roughness Comparisons" in accordance with the provisions of ANSI B46.1. Values of roughness width and waviness are not specified, but shall be consistent with the general type of finish specified by the roughness height. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection.
- (C) Unspecified surface finishes shall conform to AASHTO, Paragraph 6.7.8. Mating surfaces shall be machined to provide even, true bearing. Surfaces with rotating or sliding contact shall be highly polished and finished true to the given dimensions.
- (D) So far as practical, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Large discrepancies between adjoining unfinished surfaces shall be remedied to realize proper alignment. Depressions or holes not affecting the strength or function of the parts may be filled in a manner approved by the Engineer.

12.0 MECHANICAL COMPONENT REQUIREMENTS

- (A) Shafting, Pins, Keys, Keyways, and Set Screws: Rounds and shafts shall be true, straight and free from flaws, piping, laps, seams, or cracks. All shafts shall have

finished ends with a 60 degree lathe center with a clearance hole at the exact center of the shaft. Stepped shafts shall have fillets finished smoothly to adjacent surfaces without tool marks or scratches. Surface finish for fillets shall have a maximum roughness of 63 micro-inch according to ANSI B46.1, unless a finer finish is required.

- (B) All forged shafts shall be reduced to size from a single bloom or ingot until perfect homogeneity is secured. The blooms or ingots, from which shafts or pins are to be made, shall have a cross-sectional area at least three times that required after finishing. No forging shall be done at less than red-heat. Forged rounds for shafts and pins shall be true, straight, and free from any defect.
- (C) All shafts and pins shall be accurately finished, round, smooth, and straight; and when turned to different diameters, they shall have rounded fillets at all shoulders. Each shaft or pin having a uniform diameter of 8 inches or more and each shaft or pin having several diameters, of which the smallest is 8 inches or more, shall be bored lengthwise through the center to a diameter approximately one fifth the smallest diameter. The wall of the center bore shall be examined for cracks and fissures. Shafts and pins exhibiting defects will not be accepted. Shafts that are bored with an inspection hole shall have the ends prepared for the attachment of a centering device equivalent to the lathe center. All such devices shall be furnished as part of the work.
- (D) All journal bearing areas on shafts and pins shall be accurately turned, ground, and polished with no trace of tool marks or scratches on the journal surface or adjoining shoulder fillets. The journal bearing area shall have an 8 micro-inch finish, unless otherwise specified in the plans. Journal diameters shall be finished to the limits of an ANSI Class RC6 running fit, unless otherwise noted. Bearing seats on shafts with rolling element bearings shall have a surface finish of 63 micro-inch, unless otherwise specified by the bearing manufacturer. Fit of rolling element bearing I.D. and shaft shall be as specified by the bearing manufacturer.
- (E) Keys shall be machined for an FN2 side fit and an LC4 fit on top and bottom with keyways in shafts and hubs and a 63 micro-inch finish. Keyway corners and key chamfers shall be cut with the fillet radius and chamfer as suggested by ANSI B17.1. All keys shall be effectively held in place, preferably by setting them into closed-end keyways milled into the shaft. The ends of all such keys shall be cut square, or rounded to a half circle equal to the width of the key. Keyways shall not extend into any bearing. Keys shall preferably not extend past the end of the hub of the keyed element. If two keys are used, they shall be located 120 degrees apart.
- (F) Unless otherwise specified herein or on the plans, keys shall be made from steel squares or flats that meet the requirements of ASTM A668, Class L, or equal or greater strength alternative.

- (G) Set screws shall not be substituted for keys for transmitting torsion; they may be used only for holding keys or light parts in place. They shall be safety-type headless set screws with cup points set in counter-bored seats. Unless otherwise ordered, they shall be secured in place by use of self-locking threads.

13.0 CENTER SPAN LOCK REPLACEMENT

The existing center span lock components shall be completely removed and replaced with new center lock components as detailed on the Contract Drawings. Power and control wiring are presented in the Electrical Specifications.

The span locks shall be replaced after the new Eastbound Bridge is placed in service and all traffic is diverted off of the Westbound Bridge to the Eastbound Bridge, and the Westbound Bridge is taken out of vehicular service. If the Contractor intends to cross the Westbound bridge with vehicles or place equipment or materials on it for any reason, temporary span locks or other equivalent shear transfer means shall first be installed.

- (A) The rehabilitated span lock system shall include new span lock actuator (electric cylinder), new actuator trunnion mounting bracket, new lock bars, and new lock bar guides and receivers. The new actuator bracket, center lock bar guides and receivers are mounted to the girder webs.
- (B) The electric cylinder shall be capable of emergency manual operation by a hand wheel. The hand wheel shall have a disengaging mechanism and electric interlock switch so that the actuator will not operate electrically during manual operation. The actuator brake shall have a manual release which only works during manual operation.
- (C) The actuator shall have spring shock protection, shock absorbing elastomer rings, double wiper seal in front cap, marine epoxy coating, tropical proof corrosion protection, flexible rod cover (bellows), and stroke control limit switches.
- (D) The grease fittings for the lock bar guides and receivers shall be easily accessible from the roadway via piping to the guides and receivers.

14.0 NEW TAIL LOCKS AND MACHINERY

As part of this Project, the bascule span shall have new tail lock components installed. Four new tail locks, each with their own drive machinery, are to be installed at the four rear corners of the two leaves (two right hand and two left hand units, symmetrically opposite), as detailed on the Contract Drawings.

- (A) The side horizontal counterweight ribs on the main girder shall be modified at a centerline location 11'-0" +/- to the rear of the trunnion centerline, by adding the counterweight brackets, as shown on the Plans.

- (B) The tail lock machinery assembly consists of support weldment, gearmotor, eccentric drive, and strut. In locked position, the strut is under the counterweight bracket, installed with a small clearance. To unlock the tail lock, the gearmotor output shaft turns $\frac{1}{2}$ revolutions, and the eccentric hub assembly pulls the strut approximately vertical to clear the girder and counterweight bracket when the span is opened.
- (C) In an emergency (loss of electrical power, or malfunction of the gearmotor), the motor is supplied with a rear shaft, and manual brake release, to operate the tail lock manually with a crank. The motor protective canopy is removed to access the manual shaft. The canopy over the rear shaft extension shall contain an interlocking limit switch so that the actuator will not operate electrically with the canopy removed.
- (D) Limit switches stop the strut at the ends of its angular motion, locked and unlocked positions.

15.0 MODIFICATIONS AND REHABILITATION OF SPAN DRIVE SYSTEM

The existing Span Drive machinery and support (Hopkins) frame shall be rehabilitated as specified below and detailed on the Contract Drawings.

(A) Span Drive Reducers and External Bearings

All seals and gaskets shall be refurbished to eliminate oil leaks. Provision shall be made for a new breather on each reducer utilizing an external bladder to seal the reducer from external contamination. The bushings in each of the four external bearings which support the output shafts of the span drive reducers shall be replaced in kind.

- (C) Span drive motors, motor brakes, and machinery brake on each drive frame are to be replaced. See separate section.
- (D) The auxiliary span drive unit on each frame is to be replaced. The new gearmotor, motor brake, support weldment, and chain drive are to be installed in approximately the same location as the existing auxiliary drive. See separate section.
- (E) During and after rehabilitation of the span drive and frame, the frame shall be cleaned and re-painted. Open gearing and new bearings shall be lubricated.

16.0 SPAN DRIVE MOTOR AND MACHINERY BRAKE REPLACEMENT

The existing span brakes shall be removed and replaced with new brakes. Brakes shall be of the drum type. The brakes shall be furnished complete with an electrically driven AC

thruster type actuator. There shall be three brakes replaced per leaf (two motor and one machinery), six brakes total, including new brake wheels.

The new brakes shall be mill duty quality of the type 300M series mill duty shoe brake as designed by Magnetek/Mondel.

All brakes shall be from the same manufacturer who must have a minimum of 5 years supplying brakes to the movable bridge industry.

Brakes shall be an AC thruster type drum brake, spring set and electrically released.

Brakes shall be torque rated for 155 ft-lbs. and factory set to a torque value of 120 ft-lbs.

Brakes shall be furnished with an auto equalization assembly designed to ensure that the shoes maintain equal alignment, positive and equal braking action and equal lining wear.

Brakes shall be furnished with corrosion resistant hardware.

Brake shoes shall consist of a molded, non-asbestos type brake shoe lining that is bonded to the shoe holder.

All main pivot points on the brake shall be equipped with a bolted type composite bushing assembly. This assembly is to be comprised of an outer race component made from a composite material containing a self lubricating surface coating on the bore and a precision machined nitrided steel inner race. Pin and clip type connections are not acceptable.

The brakes shall be furnished completely assembled and must be supplied with the Eldro type thruster model "Ed" actuator. No other actuator type or manufacturer will be accepted.

The Eldro type "Ed" actuators shall be supplied with a 230/460 Volt, 3 phase, 60 HZ, totally enclosed, squirrel cage ball bearing motor with moisture proof windings, and conduit box. The thruster motor shall be of ample capacity for the intended application. The rated stalled thrust of each thruster shall be not less than 135 percent of the thrust actually required to release the brake with the torque adjusted to the continuous rated value. Brakes are to set automatically when for any reason power is removed from the thruster motor.

The oil used in the Eldro type "Ed" thruster -operating chamber shall be hydraulic oil specifically recommended by the thruster manufacturer for low temperature operation. It shall have a free operating temperature range between 13 degrees below zero and 122 degrees above zero Fahrenheit. Throughout this temperature range there shall not be any material change of operating characteristics.

All Eldro type "Ed" thruster shipped, either mounted or as a spare, must be filled with hydraulic fluid at the factory prior to shipment. All thrusters must meet IP65 standards. External thruster material shall be Aluminum for light weight and corrosion protection. Thruster motors shall be rated for inverter duty operation. The electric driving motor shall be in a separate dry section of the thruster, and air cooled. Motors immersed in oil are not acceptable.

Each Eldro type "Ed" thruster shall have the capability of being supplied with an independent time delay valve adjustable between 0 and 5 seconds for setting the brake. Only an internal time delay valve constructed of stainless steel is acceptable. Adjustment must be infinitesimally adjustable between the minimum and maximum settings. These adjustments must be allowable with the brake in full service. A single time delay for both setting and releasing is not acceptable.

Brake shoes must be easily replaced from either side of the brake without disassembling the brake. All torque adjustments should not have to be reconfigured after replacing the brake shoes.

Each brake shall be provided with a manual release lever and a device for holding the brake in the released position. The hand release attachment shall be mounted permanently on the brakes and be arranged so that the brake can be released easily and quickly without the use of apparatus not permanently attached to the brakes. This hand release shall not affect any torque setting or brake adjustment.

The hand release shall be capable of being released without removing the brake cover. The mechanism shall latch in both the released and non active positions. It shall provide at a minimum, 90% of the power release stroke and not inhibit the working stroke of the actuator when fully retracted.

Each brake shall contain three (3) lever type limit switches for use in control and indicating circuits. These limit switches will indicate brake electrically released, brake set and brake manually released. All limit switches shall be NEMA 4X rated and have two N.O. and two N.C. contacts.

Each brake shall be furnished with an external torque spring. This shall provide stepless torques adjustment down to 40% of the maximum brake torque. The actual setting must be visible from a calibrated torque indicator provided on the torque spring assembly.

Brake Enclosures

Each brake shall have a NEMA 3R outdoor rated enclosure constructed of Type 316 stainless steel; painted steel is not acceptable. The enclosures shall have slots as required, for the manual brake release handle and for the machine/motor shafts.

Brake Wheels

The existing brake wheels shall not be reused with the new brakes.

Manufacturers

The brakes and enclosures are based on Magnetek's mill duty brake (MBTE series), AISE/NEMA rated brake design.

17.0 AUXILIARY DRIVE REPLACEMENT

The existing auxiliary drive shall be completely removed and replaced with a new auxiliary drive. The new auxiliary span drive shall consist of an auxiliary gear-motor, replacement of existing chain drive with new roller chain drive, as specified on the Contract Drawings. The driven sprocket is mounted on the existing auxiliary drive shaft which is engaged by the existing clutch coupling. Install new anchor bolts, shims and other assembly hardware necessary to complete the installation, and properly align all components and the new auxiliary chain drive to the existing auxiliary drive input to the main reducer. A new stainless steel gear cover shall be fabricated to cover the auxiliary gearmotor and chain drive. There shall be one new auxiliary span drive assembly per leaf, two total.

- (A) Auxiliary Gearmotor: The auxiliary drive shall consist of a motor with brake, attached to an enclosed foot mounted reducer, SEW-Eurodrive or approved equal. The gearmotor is mounted to a new welded pedestal which is bolted to the existing span drive frame as shown in the Contract Drawings.
- (B) Auxiliary Disconnect Coupling: The gear-motor output shaft shall be connected to existing two piece auxiliary input shaft via the new chain drive and the existing disconnect coupling, with manual crank engagement.

18.0 AIR BUFFER REHABILITATION

Air buffer rehabilitation has been completed by others and is no longer a part of this contract.

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19.0 LIVE LOAD SHOES ADJUSTMENT AND SHIMMING

The existing live load shoes shall be adjusted by installing or removing shims to provide contact at both sides of each live load assembly. This adjustment shall be coordinated with the roadway profile and each live load adjustment shall be submitted for approval by the Engineer or NCDOT representative. No adjustment shall be made until approval is granted.

20.0 HIGH STRENGTH TURNED BOLTS

- (A) Turned bolts shall be made from a material and have a strength equal to ASTM A325. Turned bolts 1½" and larger shall conform to ASTM A449. Heavy hexagonal nuts and hardened washers complying with A563, Grade C, and F436, respectively shall be used with the turned bolts. Locking shall preferably be by use of double nuts.
- (B) The body of the turned bolts shall be finished to 63 micro-inch or better. Threads for the turned bolts and nuts shall conform to the Unified Thread Standards, coarse thread series with a Class 2A tolerance for bolts and Class 2B tolerance for nuts, in accordance with ANSI B1.1, unless otherwise specified. Turned bolts are designated by their nominal thread size. The turned bolt body shall be 1/16th of an inch larger in diameter than the nominal size specified, and shall have an LC6 fit with reamed holes. Bolt head and nut bearing surfaces shall be flat and square with the axis of the bolt holes and shall be spot faced if necessary. Unless otherwise noted, bolt holes in machinery parts required for connecting to supporting steelwork may be sub-drilled (in the shop) smaller than the turned bolt diameter and shall be reamed together with supporting structural steel either during assembly or at erection, after the parts are correctly assembled and aligned. Positive type locking shall be provided. Double nuts are preferred. Where double nuts are not used, heavy hex and jam nuts shall be used. Alternate locking methods shall be submitted to the Engineer for approval.

21.0 HUBS AND BORES

The hubs of all couplings, levers, and cranks shall be bored concentric with the outside diameter. All hubs shall have an ANSI Class FN2 medium force fit on the shafts unless otherwise specified. Unless noted otherwise or otherwise recommended by the manufacturer, all other hubs shall have a 63 micro-inch finish or better for a bore larger than 2 inches.

22.0 SHIMS

Where shown on the drawings, all machinery shims required for leveling and alignment of equipment shall be stainless steel, ASTM A240 or A666, Type 316, neatly trimmed to the dimensions of the assembled parts and drilled for all bolts that pass through the shims.

In general, total shim pack thickness shall be no less than twice the nominal thickness shown on the drawings, and of sufficient varying thicknesses shall be furnished to secure 0.010-inch variations of the shim allowance including one shim equal to the full allowance. Shims shall be placed to provide full contact between machinery and machinery supports. Shims shall be shown in detail on the shop drawings.

23.0 WELDING

Welding called for on these Contract Documents shall comply with AWS D1.1. Welded steel machinery parts shall be given a stress relief heat treatment prior to machining. The Contractor shall submit a schedule of the proposed stress relief heat treatment to the Project Engineer for approval. The schedule shall include a description of the part and an explanation of the proposed heat treatment, including the rate of heating, the soaking temperature, the time at the soaking temperature, the rate of cooling, and the temperature at which the part is to be withdrawn from the chamber. Soaking times of less than one hour will not be approved. Welds for supporting bridge drive machinery, and span lock (center and tail) mechanisms shall be 100% inspected by non-destructive methods. Acceptance criteria shall be that described in AWS D1.1 for tension welds.

All structural welds shall be complete penetration (cp) welds unless otherwise noted or shown on the Contract Plans. No feather edges allowed on weldments. All free edges of stiffeners, webs, and gussets must be welded. All weldments shall be stress relieved by heat after welding but before final machining.

All welding shall be by certified welders.

24.0 DELIVERY, STORAGE AND HANDLING

(A) All components and materials shall be delivered to the site in accordance with the approved schedule of work. Any special provisions used for material handling shall be provided by the Contractor.

(B) Components and materials shall be properly packaged and protected from initial shipment until the time of installation.

1. Finished and unpainted metal surfaces that would be damaged by corrosion, shall be coated with a .030" minimum film thickness, as soon as practicable after finishing, of No-Ox-Id, A-Special, as manufactured by San-Chem Company, Chicago, Illinois, or approved equal. This coating shall be removed from all surfaces prior to lubrication for operation and from all surfaces prior to painting after erection. If the anti-rust coating on any part becomes compromised prior to part installation, the coating shall be restored immediately.

C. Material storage on site shall afford easy access for inspection and identification, protection from the ground and prevent distortion or damage.

25.0 PAINTING

- (A) Cleaning and painting of machinery metalwork surfaces shall conform to the NCDOT standard requirements for structural painting and shall be indicated on the shop drawings. Factory painted machinery items shall be hand tool or solvent cleaned and overcoated with the top coat of the specified paint system in the appropriate color as indicated in this section for movable and stationary components.
- (B) Prior to fastening new mechanical components (such as weldments and supports) to the existing bridge structural elements, clean and repaint the area on the existing structure which will be in contact with the new component. Cleaning shall be with power tools to SSPC SP11 to remove rust and poor coating. New paint shall be thick epoxy mastic top coat (Carbomastic 15 as manufactured by Carboline, or approved equal). Note that the existing structure paint system may be lead based.
- (C) Machinery component surfaces to be painted shall be given one prime coat in the shop. A second touch-up prime coat shall be field applied to damaged or unprimed metalwork and a full intermediate coat applied after machinery and equipment have been installed. The final high gloss top coat shall be applied after completion of operating tests. Color for the top coat will be Federal Safety Orange for all moving parts including shafts, couplings, and brake wheels. Bearing and lubricated surfaces shall not be painted. Color for the top coat of stationary parts shall be Federal Safety Green.
- (D) Before application of paint in the shop, surfaces which require painting shall be cleaned of all chips, burrs, dirt, rust, mill scale, sand, grease, and other extraneous materials by employing methods such as chipping, grinding, wire brushing, solvents, followed by the required abrasive blast cleaning and residual removal by compressed air. Finished machined surfaces not to be painted shall be masked or shielded from abrasive blasting operations. After cleaning, surfaces requiring paint shall be painted with one prime coat. Bearing or sliding surfaces that are not painted will be coated with temporary protective materials as approved by the Engineer. Nameplates shall be clean and free of paint.
- (E) After the machinery items have been installed in final position on the bridge, all surfaces which require paint shall be cleaned of grease, oil, and loose materials by the use of solvents and compressed air, and all unprimed or damaged shop prime coated surfaces shall be repaired with the touch-up primer followed by a full intermediate coat. The Contractor shall take special care to avoid painting of machinery bearing and sliding surfaces and to mask and protect from paint these surfaces and all nameplates, legend plates, and escutcheons mounted on machinery.
- (F) After completion of the operating tests and acceptance of the machinery, all oil, grease, dirt, and other foreign matter shall again be cleaned from exposed

machinery surfaces. The exposed surfaces shall then be given a third field coat, the top coat, which shall color-code the machinery to identify fixed and moving parts as indicated previously and as shown on the shop drawings.

- (G) Should the top coat of paint submitted and approved for use on the structural metalwork not be available in the safety colors required for the machinery metalwork, a substitute top coat meeting the performance and color requirements of the top coat specified and compatible with the specified intermediate coat shall be submitted to the Engineer for approval. The Contractor shall place a cautionary sign in the Operator's House and at the entrance to the machinery area of each leaf to explain the color code. Details of the sign including text, dimensions, mounting locations, and materials shall be submitted to the Engineer for approval.

26.0 LUBRICATION

- (A) The Contractor shall furnish a lubrication plan for all new or rehabilitated machinery for approval. The plan shall be developed from recommended practice of the machinery manufacturers. The Contractor shall coordinate the lubrication plans for the various machinery elements and minimize the number of different lubricants. The Contractor shall furnish copies of letters from the various machinery manufacturers endorsing the lubricants which have been finally selected. Lubricants shall be selected for year round exposure at the bridge.
- (B) The Contractor shall provide two lever type lubrication guns with three foot hoses. Fittings shall be located in a protected and convenient position for use and shall be connected to the points requiring lubrication by pipe extensions where necessary. These pipe extensions shall be kept as short as practical and shall be rigidly supported at the fittings and at intermediate points. Pipe shall be 1/4 inch seamless threaded red brass with cast bronze threaded fittings. Fittings on proprietary parts shall be replaced if necessary with fittings that have been selected as standard for the bridge.
- (C) The Contractor shall furnish a lubrication diagram for the machinery in (A) above which shall show all points requiring lubrication, the type of lubricant to be used at each point and the frequency of lubrication. The diagram shall be submitted to the Engineer for approval and the approved diagram shall be mounted in the operator's house and in each machinery area with a suitable and approved frame and glass cover.
- (D) Lubricant compounds furnished shall be as recommended and certified by their manufacturer for the use and requirements called for. Lubricants shall be recommended for use year round with consideration to ambient temperature ranges that will be experienced by the various components. Synthetic lubricants may be proposed, but shall be compatible with all seals and sealing compounds that may be exposed to the lubricant. Contractor shall furnish the Engineer a copy of the certification.

27.0 MEASUREMENT AND PAYMENT

Mechanical work required by this section shall be measured as a single item, REHABILITATION OF WESTBOUND BRIDGE MECHANICAL WORK, complete, installed and tested. Payment shall be on the basis of a single lump sum item.

Pay Item	Pay Unit
Rehabilitated Westbound Bridge-Mechanical Work	Lump Sum

WESTBOUND BRIDGE REHABILITATION SPAN BALANCE

1.0 SCOPE

This section is intended to present the requirements associated with span balance during all phases of construction, and includes strain gage balance testing and analysis, balance monitoring throughout construction, and all required weight changes to maintain the balance requirements provided herein.

Strain gages shall be installed and data recorded to evaluate the balance condition of each leaf prior to construction and after all construction work on the moveable leaves has been completed. The Contractor shall, at the direction of the Engineer, make necessary weight adjustments, based upon the analysis of the strain gage tests. A final strain gage retest shall be performed after the adjustments are complete to validate the final balance condition of the bridge.

The Contractor shall also develop and maintain a spreadsheet that will calculate the balance condition of the movable leaves throughout the duration of the construction phase. These calculations shall be achieved by tracking all items added to, or subtracted from, each leaf and the change in balance condition resulting from such changes.

2.0 CONSTRUCTION BASCULE LEAF BALANCE

(A) Strain Gage Balancing

The Contractor is responsible for determining the balance conditions of the moveable leaves by utilizing the strain gage procedure described below. Strain gage balancing on each leaf shall be performed by the Contractor prior to beginning construction, after all construction is completed, and after balance adjustments to the span and/or counterweight have been made.

Two bi-axial strain gage rosettes shall be mounted on each shaft S1 (in between gear G1 and the final pinion), configured in such a way as to cancel the effects of bending, so that only torsional strain in each shaft is being measured. Strain in each shaft shall be continuously measured by a data acquisition system. The angle of opening of the bridge shall be simultaneously recorded by the same data acquisition system as the shaft strain.

Prior to performing strain gage measurements, the Contractor shall submit full documentation of the proposed procedure, including instrumentation equipment, strain gage mounting and wiring arrangements, and specific formulas and equations to be utilized for data analysis.

Prior to recording strain, the strain readings shall be zeroed and all static torsional loading shall be relieved from the machinery: all brakes shall be released, and all pinions adjusted such that pinion and rack teeth are not in contact. Feeler gages shall be utilized at each pinion to confirm that teeth are not in contact.

Strain gage measurements shall be taken only on a dry, calm day, with wind loads less than 5 mph, when there is no extraneous equipment, debris, rainwater, ice, snow, or other material on the bridge that would affect the balance of the spans.

Each leaf shall be tested through at least three (3) complete operational cycles and a permanent record of each test shall be maintained.

The Contractor shall submit a report of the results of the balance determination. From the strain data, shaft torque and bridge unbalance, as seen at the tip of the leaves, shall be computed and plotted against the angle of opening from full closed to full open, and from full open to full closed. A plot of raw data strain against the angle of opening shall also be included. Also included in the results presentation shall be a discussion on the peak operating torques as a percentage of the full load motor torque (when they occur and their magnitude) and system friction.

Initial balancing shall establish the existing balance baseline for use in the balance spreadsheet. If the results of the initial balancing determine that the bridge balance is outside of the acceptable balance condition for construction, the Contractor shall coordinate with the Engineer the means and methods to bring the bridge into an acceptable balance prior to the start of construction.

Post-construction balancing shall verify the construction balance spreadsheet and determine the adjustments to be made to obtain an acceptable balance condition. Final balancing shall be performed to verify that an acceptable final balance has been obtained after the adjustments.

If the final balancing results indicate that an acceptable final balance condition has not been obtained after the adjustments have been made, the Contractor shall make additional adjustments and repeat the balance testing as required until the desired balance conditions have been achieved.

Additional balance weights shall be furnished by the Contractor as required.

The testing and all balance calculations shall be performed by a Professional Engineer. The Contractor shall provide evidence of successful strain gage balancing experience on a minimum of three (3) bascule bridges within the previous five years. A complete test procedure, along with the resume of the Engineer conducting the tests, shall be submitted for approval prior to the initial balancing test.

The test procedure shall include the following:

- Test method
- List of equipment
- Sample calculations
- Report format

After the balance tests have been completed, the Contractor shall submit a formal report signed and sealed by the Professional Engineer who conducted the tests. The report shall include the following:

- Introduction
- Test procedure and Equipment
- Method of analyzing recorded data
- Presentation of results
- Conclusions
- Calculations
- Graphical representation of Span Balance vs. Opening Angle

(B) Maintaining Span Balance

Following the initial strain gage balance determination, the Contractor shall develop and maintain a spreadsheet that will determine, throughout the duration of the construction phase, the effect of all weight changes on the initial balance condition. This shall be accomplished by tracking the weight, as well as the lateral and longitudinal center of gravity locations, relative to the trunnion centerline, of all items added to, or subtracted from, each leaf. The spreadsheet will reflect the actual work plan and shall be updated daily. A copy of the spreadsheet shall be submitted to the Engineer for review prior to any work. The working spreadsheet shall be available for review by the Engineer at any time during construction. Weekly summary print-outs shall be submitted to the Engineer during construction. Temporary adjustments will be made to maintain an acceptable balance condition at all times. The Contractor shall provide, install and remove temporary balance materials as needed.

When weight adjustments are necessary to maintain the acceptable balance conditions as described below, weight shall be added to or removed from the counterweight and/or bascule leaves in accordance with the approved calculations. The bridge balance conditions shall be adjusted the same day the construction activities result in any alteration of the bridge balance, and prior to any known openings for waterway traffic. At no time shall any brakes or span locks be released or disengaged, respectively, until bridge balance has been properly restored. Brakes or span locks shall not be used for the sole purpose of maintaining the bridge in the

closed position. Instead, proper balance shall be achieved to maintain the bridge in the desired position.

Temporary equipment and tools shall be removed from the bascule spans prior to each bridge opening.

The spreadsheet and all required calculations shall be signed and sealed by a Professional Engineer. A copy of the spreadsheet and all calculations shall be submitted to the Engineer for review and approval prior to the initial balance testing.

(C) Balance Requirements

The balance for each leaf shall be maintained to meet the following requirements:

1. During Construction, Bridge Operation Not Permitted. Bridge is in the Closed Position, with Span Locks Driven.

The movable leaf must be span heavy, with a positive toe reaction between 0 lbs and 10,000 lbs with the bridge in the closed position. The center of gravity must be between -80° and $+80^\circ$ with the leaf in the closed position.

2. During Construction, Bridge Operation Permitted.

The movable leaf must be span heavy in the closed position, with a positive toe reaction between 1,000 lbs and 5,000 lbs with the bridge in the closed position. The center of gravity must be located between -80° and $+80^\circ$ with the span in the closed position.

3. Final Balance Condition of Bridge Following Construction.

The movable leaf must be span heavy in the closed position, with a positive toe reaction between 1,500 lbs and 2,500 lbs with the bridge in the closed position. The center of gravity must be located between $+10^\circ$ and $+40^\circ$ with the span in the closed position.

NOTE: The center of gravity location is measured from the horizontal on the channel side of the trunnion (i.e. an angle of $+20^\circ$ indicates the center of gravity is located on the channel side of the trunnion at an angle of 20° above the horizontal).

3.0 MEASUREMENT AND PAYMENT

Work required by this section will not be separately measured. There will be no direct payment for this span balance section, but the costs shall be included in the lump sum price bid for the Rehabilitation of Westbound Bridge Mechanical Work.

GENERAL REQUIREMENTS FOR BRIDGE ELECTRICAL WORK

1.0 DESCRIPTION

This section covers all products, labor, services, incidentals, and related work necessary to furnish, install, test, and put into permanent service all electrical work as shown on the Plans and described in the Specifications.

This section along with the following sections, comprise the Special Provisions for electrical work. The provisions and requirements of all sections of these electrical Special Provisions shall apply fully and equally to all electrical work and to all contractors performing electrical work. The provisions and requirements of this section are hereby incorporated into the sections listed below by this reference, and shall have the same force and effect as if printed in full in each of the sections listed.

- (A.) Conduit and Wiring System
- (B.) Bridge Electrical Service and Generator
- (C.) Structure Grounding and Lightning Protection
- (D.) Bridge Control System
- (E.) Main Drives
- (F.) Submarine Cables
- (G.) Traffic Warning Gates and Traffic Signals (Mast Arm Poles with Signal Heads)
- (H.) Sump Pump Systems
- (I.) Rehabilitation of Westbound Bridge Electrical and Controls
- (J.) Electrical Bridge Operation and Maintenance Manual

NOTE: See Qualifications requirements in Section 4.0, below.

NOTE: Reference to a specific manufacturer, brand, model or catalog number is intended to describe the quality and characteristics of the item or material referenced, and shall not be interpreted as excluding equivalent products by other manufacturers. All proposed substitutions shall be submitted to the Engineer for approval.

The electrical work for the control house operator's room shall be as shown on the Plans and described in APPENDIX A - DETAILED CONTROL HOUSE SPECIFICATIONS.

2.0 REFERENCES

The following publications form a part of these Special Provisions by this reference, and shall have the same force and effect as if printed herewith in full. Unless otherwise noted, the version of referenced standards or publications is the version in effect at the bid opening time for this contract.

AASHTO LRFD Movable Highway Bridge Design Specifications

NECA 1 – Standard Practice for Good Workmanship in Electrical Contracting

NETA Acceptance Testing Specifications

NFPA 70 – National Electrical Code

North Carolina Electrical Code

North Carolina Department of Transportation Standard Specifications for Roads and Structures

All applicable state and local codes

Additionally, all work shall comply with all additional requirements of the Authorities Having Jurisdiction. It shall be the responsibility of the Contractor to contact the proper Authorities prior to beginning work in order to determine all requirements, as well as to maintain relevant communications with such Authorities throughout construction.

3.0 SUBMITTALS

(A.) General Requirements

1. The contract documents are intended only to depict the general intent of this contract; they are not of sufficient detail to be used in lieu of required submittals. All required additional detail development shall be provided at no additional cost.
2. The Contractor or electrical subcontractor shall have on staff or shall retain an Electrical Engineer who shall coordinate and supervise the preparation of all electrical submittals, and fully review and check all submittal items, including those originally prepared by all sub-contractors and vendors, for compatibility with all new and existing work, and coordination with other submittal items prior to submission for compliance with the requirements of the contract documents,

(B.) Product Submittals

1. Brochures, catalog cuts and specification sheets, and other product literature for all standard or semi-standard products.

2. Certified drawings for standard or semi-standard products when requested by the Engineer, or as otherwise required by the contract documents. Certified drawings shall be provided for all motors not provided as an integral component of a piece of standard or semi-standard equipment by the manufacturer of that equipment. Certified drawings shall clearly depict all critical dimensions, as well as all electrical and mechanical ratings. Where motors are provided with special modifications (encoders, extended shafts, etc.), these modifications shall be reflected on the certified drawings. Manufacturer's standard catalog drawings are not acceptable in place of certified drawings.
3. Test certificates for raw materials or components when requested by the Engineer, or as otherwise required by the contract documents.
4. Product submittals shall be provided for all products proposed for installation, even if the proposed products are identical to those specified by the contract documents.
5. Approval shall be obtained for all submittals prior to the purchase, delivery to the site, or commitment to this project of the respective equipment or materials.

(C.) Working Drawings

1. Shop and assembly drawings for fabricated items and assemblies shall be provided prior to installation.
2. Layout and installation drawings shall be submitted for approval prior to installation of the following: electrical cabinets and equipment enclosures, conduits, cable trays, luminaires, switches, and junction boxes, traffic control equipment, any components for which mounting provisions have not been detailed on the Plans, or any components for which the Contractor is proposing alternate mounting provisions from those shown on the Plans. Layout and installation drawings shall show proposed locations, dimensions, and clearances to floors, walls, ceilings, structural members, mechanical components, and other nearby objects and equipment. Items must be shown in their proper relative positions and be dimensioned. Drawings shall explicitly show National Electrical Code required "working" and "dedicated equipment" spaces about electrical equipment. Drawings shall clearly show the Contractor's proposed method of attachment, mounting methods, specific hardware, any and all holes to be drilled or cut in structural steel or masonry, etc.
3. In areas where conduit is embedded in concrete or where sleeves are to be cast in concrete to allow raceways and/or other utility lines to pass through, detailed layout drawings shall be provided to ensure that the work is coordinated properly with structural work. The layout drawings shall show dimensioned locations, reference points, routings, and sizes of the conduits and/or sleeves. The Contractor shall be responsible for checking the information on the Plans and for generating the detailed layout drawings. The drawings shall be approved by the Engineer and the placement shall be verified prior to placing concrete in the affected area.

4. Three-line and elementary point-to-point Wiring Diagrams shall be submitted for approval prior to installation of conduit and wiring. All conductors shall be identified on the diagrams by wire numbers that match the same respective conductors or connections shown on all other component or equipment Shop Drawings or Wiring Diagrams. Each conductor shall be assigned only one wire number which shall be continuous from the origin point to the termination point of the conductor, and consistent on all diagrams on which the conductor appears, regardless of which vendor or manufacturer produced the diagrams. Wiring Diagrams are not intended to be to scale, but shall show all conduits, raceways, boxes, cabinets, and equipment enclosures, etc. Items shall be shown in their approximate geographic orientation to each other to the extent practical.
5. Conduit and raceway layout diagrams shall show each raceway utilized, with all wire numbers installed therein, in tabular or spreadsheet format. Spare conductors shall also be assigned wire numbers. Different symbols shall be used to clearly distinguish between underground, concrete encased, in-wall, and exposed conduits, as well as cable trays, flexible cables, wireways, junction boxes, terminal cabinets, equipment, and enclosures.
6. Conductor tabulations shall be provided on Microsoft Excel compatible spreadsheets and clearly indicate all wire numbers passing through or terminating in each raceway, box, cabinet, and equipment enclosure. All raceways, boxes, cabinets, and equipment enclosures shall be included on the tabulations. Tabulations shall include device served and function of each conductor. Spare conductors shall also be listed. Spreadsheets shall be set up so as to be sortable by wire number, raceway, cabinet, or equipment served.
7. Nameplate lists for electrical equipment, including proposed text shall be provided. The text of nameplates which are part of a product depicted on a shop drawing shall be clearly shown on that shop drawing.

(D.) As-Built Drawings

1. The Contractor shall maintain on site a full-size set of Working Drawings as described above, as well as Contract Plans, marked up with changes/revisions in red to reflect the as-built or as-installed conditions. Drawing markups shall include the date of the revision.
2. Such plans and drawings shall be updated weekly, so that no changes or deviations are more than one week old without being correctly recorded on the Plans and drawings. Any proposed deviations from the above required drawings, once the drawings have been approved, shall be submitted as revisions for the Engineer's approval prior to installation of the proposed revisions.
3. All drawings affected by such revisions shall be revised by the Contractor. All such as-built or as-installed plans and drawings shall be continuously available for the

Engineer's inspection in the Contractor's field office on site, and shall be turned over to the Engineer at the completion of construction.

(E.) Schedules and Procedures

1. Proposed schedules and procedures shall be submitted for approval prior to commencing work including the following:

Sequence of Electrical Work

Plan for Electrically Isolating Existing EB Bridge Prior to Demolition while keeping Westbound bridge operational

Temporary Power and Control Provisions

Temporary Roadway Traffic Controls

Temporary Navigation Lighting and Signaling

Control System Testing, Start-up, and Adjustment – EB bridge

Control System Testing, Start-up, and Adjustment – EB bridge & WB bridge

2. All proposed schedules and procedures shall be fully coordinated with the overall project schedule and approved schedule of work.

(F.) Bridge Operation and Maintenance Manual

1. At the completion and acceptance of the project, the Contractor shall develop and furnish the necessary Electrical Bridge Operation and Maintenance Manual as required elsewhere in these Special Provisions.

4.0 QUALIFICATIONS

(A.) General Requirements

1. The contract documents assume that all contractors and/or sub-contractors undertaking electrical work related to this project are properly qualified, skilled, and experienced in the type of work involved. It is similarly assumed that all vendors and manufacturers selected by the Contractor to provide products for this project are properly qualified, skilled, and experienced in the fabrication and/or manufacturer of the products involved.
2. The Contractor will not be relieved of the responsibility to satisfy the requirements of the contract documents due to lack of qualifications, skills, or experience, stated or implied, of any contractor, sub-contractor, vendor, and/or manufacturer.

(B.) Electrical Contractor

1. The Electrical Contractor shall be properly licensed by the State of North Carolina, and be primarily and regularly engaged in the installation and service of industrial electrical power distribution and control systems.

2. The Electrical Contractor shall employ on site supervisory personnel who are licensed electricians experienced in the installation and maintenance of industrial electrical power distribution and control systems.
3. The Electrical Contractor shall have been in the business of installing and servicing industrial electrical power distribution and control systems for at least ten continuous years as of the bid date.
4. In lieu of sub-contracting the electrical work to a separate Electrical Contractor, Prime Contractor personnel satisfying all of the above requirements may perform the electrical work.
5. Documentation demonstrating that the Electrical Contractor satisfies the requirements of these Special Provisions shall be provided prior to commencing any electrical work. If no separate sub-contractor is to be used, the Prime Contractor shall be clearly identified as the Electrical Contractor and documentation demonstrating that the Prime Contractor satisfies the requirements of these Special Provisions shall be provided.

(C.) General Vendors and Manufacturers

1. Vendors and/or manufacturers for electrical systems, sub-systems, and/or products, other than the control system, shall be primarily and regularly engaged in providing the items for which they are responsible.
2. Additional qualification requirements for vendors and/or manufacturers shall be as given elsewhere in these Special Provisions.

5.0 TESTING

(A.) General Requirements

1. The Contractor shall be responsible for performing all testing, inspections, and any resulting corrective work as may be necessary in order to ensure that all work is functioning properly, and as otherwise required elsewhere in these Special Provisions. All such testing, inspections, demonstrations, and any resulting remedial work, will be deemed a normal part of the contract work and will not be considered cause for delay or additional payment.
2. Procedures and equipment used for the testing required by these Special Provisions shall be in accordance with manufacturer's recommendations, NETA Acceptance Testing Standards, any other applicable industry standards, and shall be appropriate for the specific test being performed. Voltmeters, ammeters, etc. shall be true RMS type. Where recording instruments are required, they shall be three phase, strip chart or computer based type. All tools and instruments shall be specifically designed for measuring the quantity in question and be maintained in properly calibrated condition.

(B.) Electrical Testing

1. Prior to energizing any circuit or connection of any piece of equipment to any circuit, the following tests shall be performed:
 - a. Measure the supply voltage and phase rotation and verify that both are correct for the equipment installed.
 - b. Verify that all conductors and current carrying parts of equipment are continuous, free of shorts, opens, or unintentional grounds, and that all conductors are properly terminated.
 - c. Perform all testing required elsewhere in these Special Provisions.
2. In addition to the required quantitative tests, the Contractor shall also be responsible for performing all qualitative inspections which may be required to ensure that all electrical work is properly executed. Such inspections shall include, but not be limited to, the following:
 - a. Visual inspection of all electrical connections.
 - b. Visual inspection of all raceway, conductor, device, and equipment installations.
 - c. Verifying proper operation of all operating mechanisms and mechanical interlocks.
 - d. Verifying proper tightening of mechanical lugs and terminals.
 - e. Inspection of all hardware connections.
3. All portions of the electrical work, both individually and as a whole, shall be subjected to operational, as-installed, testing. Such testing shall be as required to establish that the item(s) under test meet all specified requirements and are operating in a reliable manner. The Contractor shall also be prepared to conduct any additional miscellaneous operational demonstrations as may be requested by the Engineer to establish that a given product, system, or subsystem meets all specified requirements and is operating in a reliable and safe manner.
4. For all test results which fall outside the stated acceptable values or conditions or the Engineer finds unacceptable, the Contractor shall investigate the cause of the failure, take appropriate corrective actions, and repeat the test(s). This procedure shall be repeated until such time as all test results are deemed acceptable by the Engineer.
5. Prior to doing any demolition work, the Contractor shall verify that all conductors and current carrying parts of equipment are not energized and that all power feeds have been locked and tagged out and/or disconnected at the source. The Contractor

shall also isolate or appropriately bypass any control circuits that could impact any required bridge operation. All work shall be approved by the Engineer.

6.0 WARRANTY

(A.) General Requirements

1. All product warranty certificates, and similar warranty information, shall be stored at a single location on the project site and be turned over to the Owner prior to final acceptance of the project.
2. Warranty information shall be clearly marked to identify the components covered and allow cross referencing back to the as-built contract and shop drawings.
3. Where registration is necessary as a condition of warranty coverage, warranties shall be registered to the Owner.

7.0 MEASUREMENT AND PAYMENT

The Bridge Electrical Work will not be measured, but will be paid for on a lump sum basis. This price shall include all products, labor, tools, equipment, testing, and incidentals necessary to complete the work in accordance with these contract documents.

Payment will be made under:

Pay Item	Pay Unit
New Eastbound Bridge Electrical Work	Lump Sum
Rehabilitation of Westbound Bridge Electrical Work	Lump Sum

CONDUIT AND WIRING SYSTEM

1.0 DESCRIPTION

This work consists of furnishing and installing all materials necessary for both replacement and new installation of designated conduit, cable tray, general purpose wiring, and flexible and armored cable. Also included are junction boxes and terminal cabinets and the testing of new wiring.

2.0 CONDUIT

(A.) General Requirements

1. Sleeves for conduit holes through concrete walls and floors if required, shall be PVC pipe, epoxied or cast in place. Any sharp sleeve edges shall be filed or sanded smooth.

2. Sizes shall be in accordance with the requirements of the National Electrical Code (NEC), and shall be sized to accommodate conductor pulling without damage to conductor insulation.
3. Couplings, connectors, and fittings shall be of a type specifically designed and manufactured for the application and for the conduit material. Conduit hubs shall be compatible with both the conduit and the enclosure material.
4. Where final connection to equipment with rigid conduit is not practicable, flexible, liquid-tight conduit or flexible type cables identified in this specification shall be used, such as to equipment with adjustable mountings, to navigation lights, to limit switches, and to all machinery. Flexible conduit shall be liquid-tight, UL listed. The flexible conduit jacket material shall be resistant to corrosive atmospheres, sunlight, and weather.
5. Where conduit clamps are used, the matching clamp backs shall be used to support conduits off of surfaces to which they are mounted.
6. Conduits shall not be used to support pull boxes, terminal cabinets, etc; such items shall be supported independently of the conduits.
7. Conduit threads shall be standard American National Tapered Pipe Threads. Threads shall be clean cut, straight and true, and of sufficient length to permit full-depth coupling. Conduits shall be tightened until conduit ends are together.
8. Any removal, cutting or drilling through structural masonry to allow for conduit routing shall be approved by the Engineer.
9. All conduit and cable runs for power circuits with conductors size AWG 10 or smaller and control circuits shall contain a minimum of 10% spare conductors, but no less than two spare conductors, unless shown otherwise on the Plans.
10. All major conduit runs shall include a water and UV resistant synthetic pull rope.
11. All threaded connections shall be coated with conduit thread sealant. Sealant shall be a waterproof conductive type, explicitly manufactured for the respective conduit material.

(B.) PVC Coated Rigid Metal Conduit (RMC)

1. Exterior PVC coating shall be minimum 40 mils thick. The adhesion of the PVC coating to the conduit shall be greater than the strength of the coating itself. Overall conduit shall be UL listed with the PVC coating as the primary corrosion protection and the underlying galvanized coating as supplemental protection. Interior coating shall be urethane, minimum 2 mils in thickness.

2. Field cuts to conduit shall be made square and reamed to remove burrs. Field cut threads shall have same length, dimensions, and taper as factory-cut threads. Clean field cut threads with an appropriate degreasing solvent after cutting and coat with a touch-up compound as recommended by the conduit manufacturer. Any area on the interior of the conduit which has been disturbed by reaming shall be similarly treated.
3. Plastic coated rigid metal conduit shall be installed using tools and methods which will not cause damage to the PVC coating. Any areas on the exterior of the conduit which have been damaged during installation shall be coated with an exterior patching compound as recommended by the conduit manufacturer.
4. Installers of PVC conduit shall be trained in the proper techniques for cutting, bending, threading, and repairing the PVC conduit.
5. U-bolts, conduit clamps, and mounting hardware shall have similar PVC coated construction, shall be compatible with the PVC conduit, and shall be provided by the same manufacturer as the conduit. Other hardware shall be constructed of stainless steel.
6. Shall be Robroy Industries Plasti-Bond REDH2OT, Thomas & Betts Ocal, or approved equal.

(C.) Concrete Encased Conduit

1. Concrete encased conduit shall be PVC coated rigid steel conduit as specified for use in exposed locations.
2. All open conduit ends shall be immediately capped until such time as conduit run is extended and terminated in a box, cabinet, or enclosure.

3.0 WIREWAY AND CABLE TRAY

(A.) General Requirements

1. Cable tray shall be utilized to support the major interconnection wiring within the electrical room. Cable tray shall be ladder type, fabricated from aluminum. The cable tray system shall be designed with 20% spare capacity, and shall be sized to meet NEC requirements.
2. Trapeze type cable tray supports shall be provided. Trapeze type supports shall consist of hot galvanized steel angles or channels, suspended by galvanized threaded rods. Threaded rod connections to the angle shall be double-nutted on both sides. Cable tray shall be secured to the trapeze angle with hold down clamps. Angles, channels and rods shall be sized by the Contractor, subject to approval by the engineer, to support the total cable tray plus cable load with a 1.5 safety factor. Support spacing shall be per NEC and manufacturers requirements.

3. Cable tray system shall be electrically continuous throughout. Bonding jumpers shall be provided at all flexible splices and discontinuities
4. Metal barrier strips shall be used to separate power, VFD power, and control conductors where they share the same cable tray. Mounting brackets or bolted connections for the barriers shall be placed at minimum 3' 0" spacing.

4.0 WIRING AND CONDUCTORS

(A.) General Purpose Wiring

1. All conductors shall be copper, ASTM Class B stranding. Solid conductors shall not be used. Aluminum conductors shall not be used.
2. Wire and cable for general power and control circuits shall be rated 600 volts minimum.
3. Wire and cable for drive motor power wiring shall be rated 2000 volts minimum.
4. Conductors shall be sized as shown on the Plans. Conductor sizes, if not shown on the Plans or otherwise specified, shall be minimum permitted by AASHTO for the application.
5. Conductors shall conform to the applicable requirements of UL Standard 44 and NEMA WC-70 / ICEA S-95-658.
6. Wiring, including shielded cable, shall be rated for wet locations. Wiring and cabling installed in exposed locations shall be sunlight and weather resistant.

(B.) Messenger Cable Supported Power Cable

1. Exposed power cables shall be UL Listed Type MC Power cable with Type XHHW conductors rated 600 volts minimum.
2. Cable shall have overall sunlight and oil resistant PVC jacket suitable for use in wet locations, and rated for use in cable tray, on messenger cables, and for direct burial.
3. Cable shall be Southwire or approved equal.

(C.) Multi-Conductor Control & Power Tray Cable

1. Multi-conductor cables shall be UL Listed Type MC or TC cable with Type XHHW-2 conductors rated 600 volts minimum. Cable shall have integral ground conductor.
2. Cable shall have overall sunlight and oil resistant PVC jacket suitable for use in wet locations, and rated for use in cable tray, on messenger cables, and for direct burial.

3. Cable fittings shall be specifically designed for the use with the type and size of cable. Fittings shall be provided with sealing gaskets to preserve the NEMA enclosure rating of the boxes and/enclosures they are used with.

(D.) Variable Frequency Drive Shielded Motor Cable

1. Cable shall be rated for use with AC motors in VFD applications, 100% shield coverage, with 2000V rating, UL, 3 conductor plus ground conductor, XLPE insulation, type TC-ER.
2. Shall be General Cable CVTC VFD or approved equal.

(E.) Flexible Multi-Conductor Control & Power Cable

1. Flexible cable shall be UL listed type SEOW, SEOOW, SOW, SOOW, or W extra hard usage flexible cable. Flexible cable shall be suitable for use in outdoor / exposed locations. The outer jacket shall be water, sunlight, and oil resistant thermoset.
2. Cable fittings shall be specifically designed for the use with the type and size of cable. Fittings shall be provided with sealing gaskets to preserve the NEMA enclosure rating of the boxes and/enclosures they are used with.

(F.) Telephone, Cable TV, & Ethernet Cable

1. Telephone and Cable TV cables shall be provided as required for the equipment and/or systems served. Conductor sizes, counts, and similar characteristics shall be as recommended by the manufacturer of the equipment and/or system served. Exterior cable shall have an outer jacket that is water, sunlight, and oil resistant, and shall be rated for tray or messenger cable use.
2. Ethernet cable shall be rated TIA/EIA Category 5e, NEC type CM, CMR, CMB or equivalent, and suitable for installation in raceways or cable tray. Outer jacket shall be sunlight and oil resistant PVC.
3. Ethernet cable shall be compatible with RJ45 connectors. The Contractor shall have the necessary training and tools to terminate the cable, and perform network testing.
4. Ethernet cable shall be Belden DataTuff, or approved equal.

(G.) Remote I/O Cable

1. The remote I/O cable shall be Belden No. 3072F, or equivalent as specified by the PLC equipment manufacturer, 600V rating.

(H.) Coaxial Cable

1. Coaxial cable shall be RG-11U Type, 75 ohms impedance. Cable shall have stranded copper conductor and minimum 97% copper braid shield. Jacket shall be non-contaminating black PVC. As manufactured by Belden, No. 8261 of accepted equal.

(I.) Instrumentation Cable

1. UL Listed shielded instrumentation cable with PVC outer jacket and individually shielded conductor pairs and/or triads, cable rated at 600 volts. Shall be listed as type TC or MC, overall sunlight and oil resistant jacket, suitable for use in wet locations, and rated for use in cable trays and direct burial.
2. Conductor configuration shall be as required for equipment served, minimum 16 AWG. The systems integrator shall verify that the selected cable meets the electrical requirements of the connected instrumentation and control equipment.
3. Shall be as manufactured by Okonite, Draka, or approved equal.

(J.) Fiber Optic Cable

1. Fiber optic cables shall contain eight individual 50/125 μm multimode optical fibers. Cable shall be of heavy duty, all dielectric (non-conductive) construction. Fibers shall be housed in one or more gel-filled buffer tubes. Tubes shall be bundled together with a dielectric strength member and water-blocking filler system, surrounded by a polyethylene inner jacket, aramid yarn strength member, and polyethylene outer jacket.
2. Crush resistance (EIA-455-41) shall be 2000 N/cm, or greater. Impact resistance (EIA-455-25) shall be 2000 impacts at 1.6 N-m. Operating temperature range shall be -40 Celsius to +70 Celsius.
3. Cable shall be Belden M9A843, or approved equal.

5.0 JUNCTION BOXES, PULL BOXES, AND TERMINAL CABINETS

(A.) General Requirements

1. Unless specified otherwise, junction boxes, pull boxes, terminal cabinets, and other miscellaneous wiring device boxes outdoors or in machinery areas shall be NEMA 4X weatherproof, cast aluminum or stainless steel. Doors shall be gasketed to be weather-tight, per NEMA 4. Cabinets located in the operator's house shall be NEMA 12 rated.
2. Hinges, bolts, screws, and other hardware shall be brass or stainless steel. All stainless steel cover fasteners shall be treated with anti-seize compound.

3. Terminal cabinets shall be provided with interior mounting panels for mounting of terminal strips. Cabinets that may house power and control conductors shall be sectionalized with dividers between power, VFD power, and control sections.
4. Conduit hubs shall be gasketed and caulked with sealant, and shall be located on bottoms of boxes wherever practical. Top conduit entries shall not be permitted on NEMA 4 cabinets. NEMA 4 cabinets shall include breather and drain fittings similar to Crouse Hinds Series ECD.
5. Junction boxes with threaded, screw-on type covers shall not be used. These type boxes have had some historical problems with corrosion in the cover threads.

6.0 INSTALLATION

(A.) General Requirements

1. All conduit, cable tray, wiring, junction boxes, and terminal cabinets, and support hardware shall be shown on the appropriate shop drawings, layout drawings, wiring diagrams, and other required submittal drawings and Approved by the engineer prior to installing.
2. Method of installation for all conduit and wiring shall be in accordance with contract plans, AASHTO, and the National Electrical Code (NEC). All conduits shall be supported in accordance with AASHTO requirements.
3. Apply copper impregnated conductive paste to all conductors being terminated in terminal blocks. (Does not apply to crimp-on terminal lugs).
4. Split-bolt connectors shall not be used on this project.
5. Conductors shall be pulled through conduits, enclosure and cabinet hubs, and conduit bodies in a manner that does not scrape or gouge the insulation. Nicks, gouges, and other damage to insulation will be considered sufficient basis for removal and replacement of conductors at Contractor's expense.
6. Power and control wiring shall not be combined in the same conduit.
7. No splices or taps shall be permitted in conduits, wireways, or cable trays.
8. Sharp edges and corners on fabricated mounting brackets, angles, channels, and commercial erector systems shall be removed by filing or grinding prior to installation.

7.0 TERMINAL LABELING

(A.) Conductor Identification

1. All conductors and terminal blocks shall be permanently labeled at every terminal or connection, splice, and tap. Each conductor shall be assigned an identifying number (including spares), and shall be assigned only one number throughout the entire electrical or control system.
2. Identification numbers shall be coordinated for consistency and accuracy with numbers shown on the contract plans, the Contractor's approval wiring diagrams and shop drawings, field wiring diagrams, and any other diagrams containing the same respective conductor.

(B.) Conduit and Cable Identification

1. All conduit and cable runs shall be labeled at each termination point. As with conductor identification, identification numbers shall be coordinated with the electrical drawings and diagrams.
2. Labels shall be stamped 19 gauge brass tags. Minimum size shall be 1 inch diameter. Tags shall be secured with UV resistant PVC cable ties.

8.0 TESTING

(A.) General Requirements

1. Prior to installation of new wiring, all conduits shall be inspected for any surface deformations and thread damage. Any damaged conduit shall be replaced in kind for its entire length between connections.
2. All new conductors, including power, control, fiber optic, twin axial and coaxial shall be tested for continuity and conductor identification after placement. Continuity testing shall include all necessary tests to confirm that each conductor is continuous throughout its entire run.
3. Ethernet cables shall be tested for continuity, length, data integrity, attenuation, and crosstalk. Cables that fail testing shall be replaced at the Contractor's expense. The installation shall be certified for use with the equipment to be installed.
4. PLC remote I/O communications cables shall be tested with the preferred method and acceptance criteria specified by the PLC manufacturer.
5. All new conductor insulation shall be Megger tested prior to energizing. Contractor shall measure conductor insulation wire-to-wire and wire-to-ground using an approved ground reference. All devices and loads shall be disconnected prior to Megger testing. Testing shall be done according to IEEE Standard No.4, using an

approved instrument. Minimum acceptable insulation value is 100 megohms (at 1000 Volts DC).

- 6. Supply voltages shall be measured and verified correct for the actual installed devices or equipment being served. Only after these preliminary checks may the circuit be energized.

9.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

BRIDGE ELECTRICAL SERVICE AND GENERATOR

1.0 DESCRIPTION

This Section covers the furnishing, installing and testing of power supply equipment which shall include, but need not be limited to, the following major equipment and facilities:

- New Commercial Electric Service
- Generator Pad (with Grounding system and Security Fence)
- Automatic Transfer Switch
- Diesel Generator, Enclosure, and Fuel System
- Generator Pad Load Panel and Transformer
- Generator Pad Conduit and Wiring
- Power Feed to the Control House Electrical Room
- Temporary Generators

2.0 REFERENCES

In addition to the references in the General Requirements for Bridge Electrical Work, any standards and rules of the local utility shall apply, and any applicable federal, state, and local laws and/or regulations shall apply.

3.0 SUBMITTALS

The Contractor shall request from the Utility Company, in writing, the following data regarding the new electric service. Copies of both the Contractor's request(s) and the Utility Company's response(s) shall be forwarded to the Engineer:

- Actual size of service transformer(s) to be provided
- Metering Requirements
- Transformer(s) percent impedance and X/R ratio

Three phase available short circuit fault current and X/R ratio
Line-to-ground available short circuit fault current and X/R ratio
Sizes and characteristics (material, configuration, etc.) of any
conductors to be provided by the Utility Company on the load side of the
service transformer.....

4.0 NEW COMMERCIAL SERVICE

(A.) General Requirements

1. The Contractor shall furnish all necessary materials and labor for the connection of the new electric service to the bridge. Power and metering materials, ratings, and installation shall conform to the requirements of the National Electrical Code (NEC) and of the local utility company. The Contractor shall bear full responsibility for all fees and costs associated with providing the new commercial electrical service, and with removing the existing service.
2. The new electric service shall be 480/277 volts, three phase, four wire, solidly grounded with a minimum capacity as shown on the Plans. Phase sequencing shall be ABC.
3. New metering equipment shall be provided as indicated and as required by the Utility Company.
4. The service disconnecting means shall be an enclosed circuit breaker as indicated on the Plans and satisfying the requirements for such items given elsewhere in these specifications. Disconnecting means shall be listed as "Suitable for Use as Service Entrance Equipment." Provide heavy duty laminated steel padlocks with hardened steel shackles and weather resistant thermoplastic shells, one for enclosure door, one for operating handle, and two spare. Padlocks shall be keyed alike, and shall be Masterlock No. 311, or approved equal. Weather and UV resistant warning labels satisfying OSHA requirements shall be affixed to the service disconnecting means.
5. The new electrical service shall be solidly grounded. The location of the main bonding jumper shall be in the service disconnecting means enclosure, or as otherwise directed by the Utility Company and/or as dictated by local regulations. The grounding electrode shall be as directed by the Utility Company and/or as dictated by local regulations.
6. The grounding electrode conductor(s) shall be bare or insulated soft annealed copper per ASTM B3, stranded per ASTM B8 Class B. All grounding conductors embedded in concrete shall be insulated. Conductors shall be sized as indicated and as required by the NEC. The equipment grounding conductor(s) shall be continuous and un-spliced from end to end. Exposed and direct buried grounding electrode conductors(s) shall be protected from physical damage by installation in rigid nonmetallic conduit. Conduit shall extend from the main bonding jumper

location to the grounding electrode. Conduit shall be sealed where it enters enclosure with an approved duct sealing compound.

5.0 GENERATOR PAD, GROUNDING SYSTEM, AND FENCING

(A.) General Requirements

1. The Contractor shall perform all necessary site survey work and required regulatory permitting prior to the excavation of the generator pad location. This shall include identifying the locations of any existing utilities. The Contractor shall be responsible for coordination with all utilities involved. The Contractor shall also be responsible for providing the engineering, coordination, materials and labor required to relocate any utilities affected by the generator pad construction.
2. The Contractor shall excavate the site, install the grounding rods and conductors, bonding conductors, aggregate base material, piles, and/or footings for the generator pad. It is the Contractor's responsibility to dispose of any excess excavated material in compliance with any applicable federal, state, or local regulations.
3. The Contractor shall bond and connect the grounding system to the utility grounding electrode as required by the NEC.
4. The Contractor shall provide the concrete pad with steel bar reinforcement as described on the Plans. Reinforcing shall be bonded to the grounding system.
5. A chain link fence system shall be installed on the generator pad as described on the Plans.
6. The Contractor shall provide general landscaping and paving services as necessary to contour the ground for necessary drainage and access to the pad.
7. Access ramp to the platform shall be provided as shown on the Plans.

6.0 AUTOMATIC TRANSFER SWITCH (ATS)

(A.) General Requirements

1. The transfer switch shall be listed under U.L. 1008, and rated as shown on the contract drawings. The transfer switch shall be housed in a NEMA 4X stainless steel enclosure.
2. The transfer switch shall include a retransfer inhibit input. This shall be connected to the bridge control system and shall be used to prevent transfer back to utility power while the bridge is operating under generator power.
3. The transfer switch shall have isolated relay output contacts for control system monitoring of the condition of the transfer switch. The required signals are: source 1 connected, source 2 connected, source 1 available, source 2 available.

4. The transfer switch shall have a microprocessor based controller with a digital display for monitoring power conditions and adjusting transfer switch parameters. Memory and settings shall be retained if power to the controller is lost. Features shall include programmable engine start delay timer, engine stop delay timer, transfer delay timers, transition timer, and generator set exerciser. Shall also include indicator LED lamps for source availability, source connected, and exercise/test mode. The controller shall use over/under voltage and frequency sensing with adjustable dropout time delays.
5. The transfer switch shall be 4-pole type with silver alloy contacts. The neutral poles of the transfer switch shall have the same ratings as the phase poles and shall be operated by a common crossbar mechanism. The mechanism shall be electrically operated and mechanically held in position. Normal source and generator contacts shall be positively interlocked electrically and mechanically to prevent simultaneous closing.

7.0 DIESEL GENERATOR, ENCLOSURE, AND FUEL SYSTEM

(A.) General Requirements

1. The diesel generator set, enclosure, and fuel system shall have ratings as shown on the Plans, and as described herein.
2. The complete diesel generator set, enclosure, fuel system, and automatic transfer switch shall be furnished by a single supplier who is regularly engaged in standby engine-generator sales, service, and installation, for single-source responsibility and service. The alternator shall meet the requirements of NEMA MG-1, and the generator set shall be listed to U.L. 2200, Stationary Engine Generator Assemblies and pass tests in accordance with NFPA 110 under the Prototype Test Support program.
3. The manufacturer shall confirm the size and ratings of the specific diesel generator set selected and confirm compatibility with the flux vector drives of the size and type to be installed. If determination is made that a larger size generator is necessary, the Contractor shall be responsible for increasing the size of the generator, pad, associated electrical equipment, and wiring at no additional cost.
4. The diesel generator set shall be housed in a sound-attenuated and weather protective aluminum enclosure with stainless steel hardware. The generator set shall also include a dual wall sub-base fuel tank sized for 24 hour capacity at 25 percent load. Fuel tank shall include primary tank leak detection, low level fuel switch, and direct reading fuel level gauge. The cooling system shall include an integrally mounted radiator system. All inlets and outlets shall be provided with rodent barriers. Enclosure shall be equipped with exterior oil and coolant drains with interior valves for ease of service.

5. Fuel shall be No. 2 diesel. Engine emissions shall be certified compliant with EPA stationary diesel generator set requirements in effect at the engine build date. The exhaust system shall be furnished with a residential grade silencer.
6. The diesel generator shall be equipped with a heavy duty 12 volt DC negative ground battery(ies) for engine starting, 100 amp battery charging alternator, and 120VAC battery trickle charger. A 120VAC thermostatically controlled heater shall be provided for the coolant system, lube oil system, and alternator. Alternator shall have class H insulation, and temperature rise shall be 125 degrees C (standby).
7. A generator main circuit breaker shall be furnished, having minimum ratings as shown on contract plans, and shall be U.L. 489 listed for 100% continuous operation and U.L. 869A for use as service equipment.
8. The generator control system shall provide total system integration, including automatic remote starting / stopping, precise frequency and voltage regulation, alarm and status message display, current protection, output metering, and auto-shutdown at fault detection. Local control shall provide for starting and running the generators without transferring the load.
9. The Contractor shall provide all fuel required for the diesel generator set up through and including testing, and shall fill the fuel tank of the new generator to full capacity after all testing is completed and the generator set along with both EB and WB bridge electrical systems are completed and accepted.

8.0 TEMPORARY GENERATORS

(A.) General Requirements

1. The Contractor may utilize temporary generators as necessary to support construction activities and to maintain bridge operation, traffic control and signaling, and navigation lights during construction.
2. The Contractor shall provide temporary power wiring and power receptacles as required by the work being performed. Temporary power wiring shall be routed and mechanically protected so as not to cause tripping and/or shock hazards to pedestrians. Any damaged wiring shall be promptly replaced or repaired in a manner approved by the Engineer.
3. Temporary generators shall be grounded and shall have over-current protection as required by the NEC.
4. The Contractor shall provide all fuel required by temporary generators.

9.0 TESTING

(A.) General Requirements

1. The Contractor shall furnish all materials, equipment, fuel and labor to conduct all tests required herein. The Engineer shall be notified in advance of all tests and shall have the option to witness the tests. Written records of all tests shall include the type of test performed, date, personnel involved, equipment tested, name of test equipment or instrument used for the tests with serial number and test results. Test reports shall be signed and dated by the contractor and submitted to the Engineer or other representative of the Department for review.
2. Prior to energizing, the service equipment shall be inspected for any unintentional grounding, phase reversal of feeder connections, short circuits, and the equipment is connected and wired as shown on the approved working drawing.
3. The Contractor shall perform all tests and inspection recommended by the equipment manufacturer and the electric utility company, unless specifically waived by the Engineer or by the representative of the Department. The Contractor shall engage the manufacturer's field service technician or engineer to perform the testing of the diesel generator and transfer switch.
4. When the entire installation of all electrical systems of the bridge is complete, the Contractor shall perform operational tests of the diesel generator and the transfer switches as a complete electrical service system to demonstrate that all of the electrical service equipment functions properly.

10.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

STRUCTURE GROUNDING AND LIGHTNING PROTECTION

1.0 DESCRIPTION

This section covers all products, labor, services, incidentals, and related work necessary to furnish, install, test, and put into permanent service the structure grounding and lightning protection system as shown on the Plans and described herein.

2.0 REFERENCES

All structure grounding and lightning protection work shall comply with NFPA 780 – Standard for the Installation of Lightning Protection Systems, and the National Electrical Code.

3.0 SUBMITTALS

(A.) Working Drawings

1. Layout and installation details for the bridge grounding system shall be submitted for review and approval. Drawings shall show grounding arrangements for the bridge structures and the new control house.
2. Information shall include, but not necessarily be limited to: ground electrode types, sizes, and locations, ground conductor types, size, and routing, location of connections, and hardware used.

4.0 MATERIALS

(A.) Air Terminals

1. Unless otherwise noted on the plans, air terminals shall be UL Listed, 1/2 inch diameter, tin plated copper, safety type with a 3/4 inch diameter sphere tip. Length shall be as noted. Air terminals shall be Harger STAT 2000, or approved equal.
2. Air terminal bases shall be UL Listed electro-tin plated bronze. Flat surface bases shall be bolt-on type, secured with Type 316 stainless steel hardware. Pipe railing bases shall be clamp-on or u-bolt type. Conductor connection to bases shall be by mechanical clamp. Air terminal bases shall be as manufactured by Harger, or approved equal.

(B.) Conductors

1. Unless otherwise noted, all main conductors, down conductors, and jumpers shall be UL Listed Class II uninsulated main conductors, constructed from 28 strands of 14AWG copper wire, and having a cross sectional area of not less than 115,000 circular mils. Nominal outside diameter shall be 1/2 inch, and nominal weight shall be 375 pounds per 1000 feet. Conductors shall be Harger No. 28T, or approved equal.

(C.) Exothermic Welds

1. Exothermic welding system shall be specifically designed for use in making grounding and lightning protection connections. System shall utilize weld material consisting of a mixture of copper oxide and aluminum powder which, when ignited, produces a molecular bond. Exothermic welding system shall be ERICO CADWELD, or approved equal.

(D.) Grounding Electrodes

1. Grounding electrodes for structural grounding and lightning protection shall be solid copper one-piece or sectional ground rods. Sectional ground rods shall be

threaded with matching threaded couplers. Minimum size for ground rods shall be 1 inch diameter by 10 feet long.

2. Ground rods shall be driven vertically near the bridge piers. Where rock or other underground obstructions are encountered ground rods may be driven according to the alternate methods described in NEC Article 250, in which case the Contractor shall immediately notify the Engineer of the obstruction and the Engineer may require the installation of additional ground rods.
3. Locations of any under water utilities and/or submarine cables shall be verified before any grounding rods are installed.
4. Ground rods shall be driven to a depth of at least 12 inches below the mud line (measured from the top of the rod). Conductor connections to ground rods shall be made below the mud line.
5. Ground electrodes shall be as manufactured by Harger, or approved equal.

(E.) Cable Supports

1. Cable supports for attachment to structural steel shall be one-hole type copper loop straps. For connection to structural steel, straps shall be secured with Type 316 stainless steel machine screws in tapped holes. For connection to concrete, straps shall be secured with Type 316 stainless steel adhesive anchors and bolts.

5.0 INSTALLATION

(A.) General Requirements

1. All components shall be securely mounted and supported. All hardware shall be bronze or Type 316 stainless steel. All bolted connections shall utilize lock washers.
2. All conductors shall be routed neatly, and as directly as possible. Sharp bends shall be avoided to the extent practical. Conductors shall be supported at maximum 3 foot intervals.
3. Conductor splices shall be minimized. Conductor splices shall be by exothermic welding.

6.0 CONTROL HOUSE LIGHTNING PROTECTION

(A.) General Requirements

1. The control house shall have a lightning protection system installed as shown on the Plans.
2. Bonding connections to the lightning system shall be provided for isolated metallic bodies and grounded metal bodies on the control house according to NFPA 780.

7.0 EB AND WB BRIDGE GROUNDING

(A.) General Requirements

1. At each bridge trunnion, insulated flexible bonding jumpers of AWG 2 type W portable power cable shall be installed and solidly grounded. The jumpers shall be installed as shown on the Plans. The jumpers shall have adequate slack loop to allow for the full motion of the bridge.
2. Any welded or cleaned areas shall be restored to match the finish of the surrounding steel.

8.0 TRAFFIC GATE, TRAFFIC LIGHT, AND ROADWAY LIGHT GROUNDING

(A.) General Requirements

1. A grounding electrode shall be installed for each traffic gate, traffic light pole, and roadway light pole. The electrode shall be installed at the bridge pier closest to the gate or pole to be grounded.
2. Each traffic gate arm and housing shall be solidly grounded to the grounding electrode as shown on the Plans.
3. Each traffic light pole and roadway light pole shall be solidly grounded to the grounding electrode with a down conductor and a heavy duty bronze bonding lug at the pole base anchor point.

9.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

BRIDGE CONTROL SYSTEM

1.0 DESCRIPTION

This Section covers the furnishing of all labor, material, equipment, devices and related appurtenances to install, test and put in permanent operation a complete programmable controller system, as shown on the contract plans and described herein.

2.0 QUALIFICATIONS OF CONTROL SYSTEMS VENDOR

(A.) General Requirements

1. Each bidder shall identify the intended Control System Vendor (assembler/supplier of the integrated control system), and submit a sufficient previous experience log to verify that the Vendor meets the requirements listed herein. The equipment furnished by the Control System Vendor shall include, but not necessarily be limited to, the PLC and all associated components, the PLC program, resolvers, encoders, limit switches, flux vector drives, motor control center and the bridge control console.
2. The Control System Vendor must be able to demonstrate experience in movable bridge control systems by having completed five previous successful movable bridge control systems, at least three of which shall have incorporated a PLC system with flux vector variable speed drives.
3. All required previous project references, including names of bridge owners and contact persons with phone numbers, must be submitted to the Engineer.
4. The Control System Vendor's PLC program developer shall be on site during initial startup and testing of the control system for the new EB bridge, and then again for startup and testing of the new control system and flux vector drives on the existing WB bridge.
5. Control System Vendors unable to demonstrate compliance with the above requirements will not be accepted.

3.0 PLC SYSTEM

(A.) PLC

1. Bridge control logic functions shall be performed by a programmable logic controller, such as a Model SLC 5/05 or ControlLogix, as manufactured by the Allen-Bradley Company, or equal accepted by the Engineer. The PLC processor shall utilize ladder-logic programming, with an advanced instruction set including: file handling, sequencing, diagnostics, shift register(s), program control instructions, timing, and mathematical functions. Processor memory shall be 64K or larger, battery backed static RAM. Processor shall be capable of interfacing with up to 4096 inputs and 4096 outputs, with a scan time of 20 milliseconds or faster. Processor shall include built-in Ethernet and RS-232 ports.
2. In general, except for traffic control and other specific exceptions as may be granted by the Engineer, all control logic, timing, counting and other control functions shall be performed by the PLC. All necessary modules, interfaces internal and external to the controlled equipment, and other accessories shall be included to provide a

complete working system. Interconnection between processors and I/O racks shall be via Remote I/O utilizing twin axial cable.

3. Two identical PLCs shall be provided, each with its own dedicated power supply. Both PLCs shall be installed and wired in place. One shall be active, and the other shall be in totally de-energized reserve. The reserve PLC and its power supply shall be electrically-isolated from the power source and I/Os via a multi-pole transfer switch or relay(s). Transfer shall be performed via a maintained position selector switch mounted on the front of the PLC cabinet door. Upon transfer, the previously active PLC and its power supply shall be de-energized and electrically isolated.

(B.) PLC EQUIPMENT ENCLOSURES

1. The primary PLC cabinet shall be freestanding style, NEMA 12, constructed of 12 gauge steel. Powder coated finish (outside and inside). The cabinet doors shall incorporate suitable size plexiglass windows to provide clear observation of status indicator lights on all PLC's, I/O cards, and all other related peripherals. The cabinet shall incorporate a door switch operated interior lighting kit, a utility receptacle, and a cooling fan/filter kit powered from a separate circuit.
2. Remote I/O cabinets shall be a wall mounted, NEMA 4X, constructed of 14 gauge stainless steel. The cabinet shall incorporate a door switch operated interior lighting kit, a utility receptacle, and a thermostatically controlled heating / anti-condensate element powered from a separate circuit when located in nonheated damp or wet locations.
3. All point-to-point wiring internal to the drive cabinets shall be stranded copper. Control wire shall be minimum 14 AWG. Power wire shall be sized as required.
4. All spare PLC I/O points shall be assigned wire numbers and wired to terminals for future use.

(C.) Relays

1. Control relays shall be UL listed machine-tool relays. Relay contacts shall be field reversible cartridge type, number as required, plus one spare contact. Contacts shall be rated at least 10 amperes at 300 volts AC, 60 hertz. Relay coils shall be 120 volts AC, 60 hertz. Control relays shall be Allen-Bradley 700-N, or approved equal.
2. PLC isolation relays shall be provided for all motor starters and other large loads, and as shown on the Plans. Relays shall be UL listed general purpose plug-in type relays with DPDT contacts rated 10 amperes at 300 volts AC, 60 hertz. Relay coils shall be 120 volts AC, 60 hertz. Relays shall include pilot light and manual operator. Sockets suitable for DIN rail or panel mounting, with retainer clips, shall be provided for each relay. Isolation relays shall be Allen-Bradley 700-HA, or approved equal.

(D.) Alphanumeric Display

1. Message display shall be a two line LED matrix display as indicated on the Plans. Characters shall be at least 0.7 inch high, and no less than 20 characters per line.
2. A licensed copy of the programming software, any necessary programming cables, and a backup file for the Alphanumeric display configuration shall be provided.
3. The programmable controller shall be programmed to display variable messages on the control console message display for specified faults or conditions. When not providing specific status messages, the display shall show the current date and time of day.
4. Messages shall include, but not necessarily be limited to, specific information about all faults and warnings.
5. When a flux vector drive fault occurs, the PLC shall interrogate the faulted drive via the Ethernet communication link and display specific information about the nature of the fault.

(E.) Touchscreen Display

1. A touchscreen PC computer based display shall be mounted in the door of the PLC cabinet. The most current version of Allen-Bradley RS-View software, or equal accepted by the Engineer, shall be installed and configured to provide PLC operator interface, alarming, and data acquisition.
2. The touchscreen display shall have a 15 inch minimum, backlit, color, active matrix display with analog resistive screen. Display shall support 1024x768, 18 bit color. The touchscreen shall communicate with the PLC using Ethernet.
3. The touchscreen display shall be configured to provide a backup control point for the bridges. Multiple screens, organized by function, shall be used to prevent clutter and improve readability. A simple menu system shall be accessible from any screen to allow an operator to quickly switch to any other screen with minimal manipulation of menu options.
4. The current on/off status of each individual PLC digital input and output shall be available from dedicated I/O list screens. A text description for each input and output device shall include the PLC address and a description of the physical device that is referenced.
5. The touchscreen display shall permit viewing of real-time and historical data acquisition information.

6. The touchscreen display shall permit maintenance adjustment of control system parameters such as timer delays, setpoints, operating speed, etc, within safe ranges. Adjustment of such parameters shall be password protected.
7. A keyed selector switch shall be installed in the PLC cabinet door adjacent to the touchscreen display to select between the following modes: "OFF", "MONITOR", and "CONTROL". In "OFF" mode, the touchscreen shall be powered off. In "MONITOR" mode, it shall be possible to monitor bridge control system operation, but not control any bridge operating functions. In "CONTROL" mode, the normal control console shall be locked-out (status monitoring still functional via indicator lights) and control shall be from the touchscreen display. The selector switch shall be maintained in "OFF" and "MONITOR" positions, but spring return to "MONITOR" from "CONTROL". If the selector switch is released during operation, a normal stop shall be initiated. The touchscreen display keyed selector switch shall be keyed differently from the control console control power switch.
8. Current active faults and VFD operating status parameters shall be viewable from the touchscreen.

(F.) Laptop/Notebook Computer

1. A semi-ruggedized laptop/notebook computer shall be included, with all necessary software, cables and interface module for programming the PLC. Programming capabilities shall include both on-line and off-line programming. The software and interface module shall be furnished by the PLC manufacturer, and shall include extensive documentation. The software shall have provisions for: programming in ladder logic-type graphics language, rung, address and instruction comments, program listings, cross-reference reports and contact histograms.
2. The laptop/notebook computer shall meet the following minimum requirements, unless specified otherwise by the PLC manufacturer: 2.1 GHz (or higher) processor, 2Gb system RAM, minimum 160 Gb shock-mounted hard disk drive, built in touchpad, 24X (or higher) CD-RW / DVD-R, external mouse and pad, 56Kbps internal modem, internal Ethernet adapter, 15.6" 1280x800 WXGA outdoor-readable TFT active matrix color LCD display, and Windows 7 Professional operating system. Ports shall include USB 2.0, and 10/100 Ethernet ports. The notebook computer shall be moisture, dust, vibration, and drop-shock resistant, and designed using MIL-STD-810F test procedures. Shall include a 120-volt AC power adapter. The computer shall be mounted on a dedicated shelf inside the PLC cabinet. The computer shall be Panasonic Toughbook 52, or approved equal. All original manuals, software packages, software license information, and packaging material for the computer shall be provided.

(G.) Miscellaneous

1. A modem shall be provided and installed in the PLC cabinet. Modem shall provide for remote monitoring of PLC operation and data acquisition through normal telephone circuits. Provide surge suppressor in telephone line ahead of modem.
2. Ethernet switch(s) shall be provided as required to network the PLC (active or backup) to the VFD's and touchscreen, and to provide multiple remote programming ports. Ethernet switches shall be industrial type and shall be housed in control panels or suitable enclosures.
3. The Contractor shall submit a complete detailed interconnection diagram between all components and a list of equipment to be furnished for approval prior to starting his electrical work. Wire numbers shall be provided on the wiring diagrams. All electrical work shall be strictly in accordance with the requirements of the National Electrical Code.
4. For each PC based system, a licensed copy of hard drive imaging software shall be provided and installed. At the completion of the project, a hard drive image backup file for each PC shall be supplied to the Department. The hard drive imaging software shall be as specified by the Department.

4.0 PROGRAMMING

(A.) General Requirements

1. The PLC logic shall assure correct sequence of manually initiated operations, and control fully automatic operations.
2. The ladder logic shown on the Plans is conceptual only. Additional logic development and program writing by the control system vendor will be necessary to complete the program suitable for operating the bridges.
3. The documented ladder diagram program shall be furnished with the shop drawing submittals for approval at least two weeks prior to the control system shop test. Control system shop drawings will not be approved without the ladder-diagram program.
4. Bypass Switches mounted on the control console serve to bypass conditions that would otherwise prevent operation from continuing using the PLC. The Bypass Switches always override the limit switches on the devices for which they are named. For example: Span Locks Pulled Bypass completes all lock pulled limit switch actions so that the PLC believes that the span locks have successfully pulled.
5. The program shall be written so that once a Bypass switch is activated, the bridge will complete only that one activity, after which the Raise and Lower circuits will both be locked out until the Bypass is restored to its normal non-bypassed position.

Example: If a Bypass must be used to complete the Lower operation, it must be reset, and again activated when required before the bridge can be raised. Stopping the Raise or Lower shall function as a completion in terms of the above described lock out feature.

6. Faults Handling

- a. Faults are shown on the main control console with dedicated indicator lights, on the alphanumeric display, and on the touchscreen display. If multiple faults are assigned to one indicator light (ex. MCC Motor overload fault), a specific description of the cause shall be shown on the alphanumeric display and on the touchscreen display.
- b. The bridge operating sequence will be interrupted if certain critical faults occur or an interlock is not satisfied.
- c. The operator investigates the fault or calls for assistance. If the condition is determined safe to be bypassed, the operator will activate the applicable bypass keyswitch.

7. The PLC processor and most I/O modules are intended to be left continuously energized, regardless of the position of the Control Power switch. Control logic shall be so written that in the event the PLC processor is de-energized at any time either during bridge operation or periods of inactivity, it shall automatically initialize itself and be ready to resume either raise or lower upon restoration of power without regard to the mode or position of operation immediately prior to the de-energizing.

8. Manual Mode

- a. In the event of a problem, or to perform troubleshooting, each bridge can be operated in a manual mode. The manual mode requires the bridge operator to step the operation through the sequence manually. The slow (span) speed is selectable only in manual mode.
 - b. Normal control interlocking is still performed in manual mode to prevent operations from being performed out of sequence.
 - c. Manual mode allows for individual control of the span locks, tail locks, and raising / lowering of the nearside and farside spans without automatically progressing to the next step in the sequence.
9. The normal control mode allows both (EB and WB) bridges to open and close at the same time. A selector switch on the main control console is used to provide individual control of bridge operations for testing, troubleshooting, or for operation under generator power.

10. The Systems Integrator shall develop the PLC logic in two phases as follows:
 - a. Phase 1 – The first phase shall include all logic necessary to operate both EB & WB bridges. The logic and alarming for the WB bridge shall be temporarily disabled.
 - b. Phase 2 – The second phase shall include all logic necessary to operate both the new EB bridge and the rehabilitated WB bridge. All logic shall be enabled.

5.0 DATA AQUISITION

(A.) General Requirements

1. Data acquisition shall be provided, installed, and demonstrated to include the features and capability as listed in this section.
2. Data acquisition shall be accomplished utilizing the touchscreen PC computer, operator interface software, and custom software.
3. The touchscreen PC shall be capable of communicating and acquiring data for all of the analog and digital points in the system, plus all spare points. (A "point" references a single address in the PLC that corresponds directly to a memory locations) It shall be possible to select the rate at which data points are sampled.
4. The supplied software must be capable of producing professionally-formatted reports on real-time information, as well as historical information contained in data logs, alarm logs and activity logs. It must be possible to print these reports to a disk or printers.
5. Specific data to be recorded includes the following:
 - a. Time and date at Traffic Signals Red
 - b. Time and date at Control Power On
 - c. All PLC digital I/O states at Control Power On
 - d. All PLC digital I/O state transitions (with time/date stamp and span positions)
 - e. Bypass usage (with time/date stamp)
 - f. Manual mode usage (with time/date stamp)
 - g. All alarms and faults (with time/date stamp)
 - h. Motor digital signals, torques and speeds at 2-3 second intervals during operation

- i. Span positions (Nearside and Farside) at 2-3 second intervals
 - j. Time and date at Control Power Off
 - k. Time and date at Traffic Signals Green
6. Parameters to be recorded for each bridge operation include:
 - a. Duration of roadway traffic disruption for each bridge
 - b. Raise times for each span
 - c. Lower times for each span
 - d. Maximum torque for each span
 - e. Number of warnings and faults
 7. Cumulative parameters to be recorded include:
 - a. Total usage of each bypass switch
 - b. Total span operations for each bridge
 8. The software shall be designed to facilitate future expansion and modification.
 9. All of the necessary software, licenses, and hardware required to design, program, test and implement the system shall be supplied.

6.0 PRELIMINARY TESTING

(A.) General Requirements

1. The PLC panel, remote I/O panels, control consoles, flux vector drives, and MCC's shall be used to perform the preliminary test.
2. All PLC controllers, relays, and other internal control system components shall be assembled in the proper cabinet(s), ready for preparation for shipping (pending any corrections or adjustments necessitated by testing results) before performing this test.
3. The control console, the various motor contactors, and the flux vector drives shall also be connected and utilized for this test. In general, the various motors need not be present, but temporary indicator lights shall be provided and energized through the power contacts of the motor contactors, and labeled according to the direction of motor rotation (ie, raise, lower, etc) where applicable. Small motors shall be used with the flux vector drives.

4. Toggle switches and/or selector switches, properly labeled and configured, may be substituted for limit switches for this test. All operations of the control sequence must be demonstrated for this test. Any errors found in the system shall be corrected and the test rerun, to the satisfaction of the Engineer.
5. This test shall be conducted in the presence of the Department's representative. Accordingly, the Department shall be notified at least two weeks prior to the test date.

7.0 STARTUP SERVICES

(A.) General Requirements

1. Startup services will be required for two separate time periods:
 - a. Startup of new Eastbound Bridge
 - b. Startup of Rehabilitated Westbound Bridge
2. The Control System Vendor shall provide a factory trained field engineer/technician to check out the control system installation on-site, including wiring interconnections as they relate to the control system, prior to the initial operation of the control system. The vendor's field engineer/technician(s) shall remain on-site during system startup for any required adjustments or modifications of the control logic and the flux vector drives.
3. The field engineer/technician will provide at least three days (eight hours per day) of operating and trouble shooting instructions to the operation and maintenance personnel. The overall project need not be accepted for the instruction period to commence, but the control system operation must be deemed satisfactory by the Engineer and in need of no further major adjustments or modifications. This approval to begin the instruction period does not imply final acceptance of the project or any part thereof.
4. The Control System Vendor shall also acquire the services of the flux vector drive manufacturer's field services engineer/technician to be on-site during the startup and adjustment period as described in the Main Drives specification. Initial operation of the bridge will not be permitted in the absence of either of these two manufacturers' personnel.
5. Any travel and on-site costs for the Control System Vendor shall be included in the bid price.
6. The field engineer/technician will keep a marked-up hard copy of the PLC ladder logic listing on site at all times. The field engineer/technician shall also maintain electronic backups of the PLC ladder logic program on site.

8.0 AS-BUILT DOCUMENTAION

(A.) General Requirements

1. The Control System Vendor shall provide hard copies of the as-built PLC ladder logic program listing complete with all cross references, contact labels, and rung comments. The labels on all input and output points shall match those shown on the contract drawings. One copy shall be provided for the main control panel, and other copies shall be supplied as required by the Electrical Bridge Operation and Maintenance Manual specification requirements. An electronic "PDF" version of the program listing shall also be provided.
2. The Control Systems Vendor shall provide an electronic backup of the PLC ladder program, contact labels, program labels, PLC configuration, and all related files in a format that can be read and downloaded by the PLC programming software. These files shall also be copied to the hard drive of the notebook computer.
3. As-built electronic backups shall be provided for the touchscreen application and alphanumeric displays. All reference data files and source code shall be provided.
4. Hard drive image files for all PC's.
5. Electronic backups shall be provided on compact disk, or a media approved by the Department. Six copies shall be provided.
6. All passwords shall be provided to the Department.

9.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITAION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

MAIN DRIVES

1.0 DESCRIPTION

This Section covers the furnishing of all labor, material, equipment, devices and related appurtenances to install, test and put in permanent operation a complete new flux vector type variable speed main drive system as shown on the contract plans and described herein.

2.0 SUBMITTALS

(A.) General Requirements

1. Manufacturers catalog sheets shall be submitted for all main drive system components.
2. Complete shop drawings shall be submitted for the main drive system. Shop drawings shall include complete wiring diagrams showing internal and field interconnection of all drive system components, dimensioned cabinet layout drawings, and dimensioned dynamic braking resistor drawings.
3. Submit calculations verifying dynamic braking resistor sizing and selection.
4. Submit manufacturer's installation and operation manuals for all components. Manuals shall be new, bound copies, and shall be edited to remove information not related to the actual model(s) and options provided.
5. Submit a complete listing of drive programmable parameters showing the proposed setting(s) for each. Where necessary, provide commentary to explain purpose of settings.

3.0 MATERIALS

(A.) Flux Vector Drives

1. Three phase AC drive providing true closed loop (encoder feedback) flux vector speed and torque control of the AC induction drive motor.
2. Drive shall utilize microprocessor based control. Shall include an operator interface, with backlit LCD display and keypad, usable for drive status monitoring and adjustment of all parameters.
3. Operating modes shall be fully programmable and selectable via external control inputs as required. Drive shall be configured for operation as depicted on the drawings. Drive shall include built in communication capability including Ethernet.
4. Drive shall provide for at least three (3) preset speeds selectable via external discrete control input, independently adjustable acceleration and deceleration times, and two (2) independently adjustable torque limit settings selectable via external discrete control input to allow for a reduced bridge seating torque.
5. Drive shall provide for means to stall seat the bridge for at least five (5) seconds without a drive fault occurring.
6. Drive shall be capable of producing 150 percent full load torque at the drive motor for 60 seconds, and at least 175 percent for at least ten seconds.

7. Drive shall include line side and load side contactors, line side and load side line reactors, fused control transformer, interfacing control relays (with internal indicator lights), terminal blocks, and any other devices and accessories necessary to complete the drive assembly. Drive enclosure door shall include an array of pilot lights as indicated on the Plans.

(B.) Drive Enclosures

1. Enclosures shall be heavy duty, free standing, NEMA 12 industrial control enclosure with disconnect. The disconnect operator shall be mechanically interlocked with the cabinet door and lockable in the off position.
2. The enclosure shall have a cooling fan/filter kit and an anti-condensation heater. A thermostat(s) shall be used to control the cooling fan and heater operation. Both devices shall not operate at the same time, and there shall be a small temperature dead-band where neither device shall not operate.
3. Drive interfacing relays shall be identical to PLC system interposing relays.
4. All point-to-point wiring internal to the drive cabinets shall be stranded copper. Power wiring shall use Type XHHW insulation, sized as required. Control wire shall be minimum 14 AWG.
5. **NOTE:** The dimensions shown on the Plans for the drive cabinets SHALL NOT BE EXCEEDED in order to maintain NEC required working clearances in front of the cabinets. The Contractor is alerted that not all manufacturers offer drives dimensionally compatible with these requirements.

(C.) Dynamic Braking Resistors

1. Dynamic braking resistors shall be sized to provide 150 percent braking torque.
2. Resistors shall be sized for a duty cycle consisting of 30 seconds on at 150 percent, then four and one half minutes off.
3. Resistor cabinets shall be NEMA 1 ventilated cabinets with ventilation openings screened or otherwise protected to prevent entry of small rodents.
4. Resistor cabinets shall be designed to be stacked, one over the other, with the assumption that only one of the two resistor cabinets in the stack will be active at any given time. Cabinets shall be sized appropriately for the space in which they will be installed.
5. Each resistor cabinet shall include a small junction box with terminal blocks, mounted on an isolating metal standoff bracket to hold the box several inches off of the side of the cabinet. The terminals in the junction box shall be connected to the

resistors by high temperature wiring in flexible metal conduit of 24 inch minimum length.

4.0 PRELIMINARY TESTING

The main drives shall be tested in conjunction with the PLC, motor control center and control console and witnessed by the Engineer and Department's representative(s) before shipment to the project site. Tests shall be in accordance with the bridge control system testing procedure outlined elsewhere in these Special Provisions.

5.0 STARTUP SERVICES

(A.) General Requirements

1. Startup services will be required for two separate time periods:
 - a. Startup of new Eastbound Bridge
 - b. Startup of Rehabilitated Westbound Bridge
2. The Control Systems Vendor shall acquire the services of the flux vector drive manufacturer's field services engineer/technician for commissioning and startup of the drives.
3. The field services engineer/ technician shall thoroughly evaluate all power and control wiring prior to the first application of power to the drives and correct any errors found. The field services engineer/ technician shall make any final adjustments as may be necessary for proper and reliable operation, and as may be directed by the Department.
4. The field services engineer/ technician shall remain on-site until it is satisfactorily demonstrated to the Department that the drives are operating reliably and properly and that no further adjustment is necessary.
5. Training on the main drives, including programming and troubleshooting, shall be provided as part of the control system training described elsewhere in these special provisions.
6. Any travel and on-site costs for the field services engineer/ technician shall be included in the bid price.

6.0 AS-BUILT DOCUMENTAION

(A.) General Requirements

1. The Control System Vendor shall provide hard copies of the as-built drive parameter listings for each drive. One copy shall be provided for the drive panel, and other copies shall be supplied as required by the Electrical Bridge Operation

and Maintenance Manual specification requirements. An electronic "PDF" or text file version of the drive parameter listings shall also be provided.

2. If parameter backup software is available from the flux vector drive manufacturer, provide as-built electronic backup files of each drive's parameters and the appropriate licensed copy of the software, manuals, and necessary programming cable. Provide configured memory card backup of drive parameters when available from the flux vector drive manufacturer.
3. Electronic backups shall be provided on compact disk, or a media approved by the Department. Six copies shall be provided.
4. All passwords shall be provided to the Department.

7.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

SUBMARINE CABLES

1.0 DESCRIPTION

This section covers all wiring and related labor and appurtenances used to furnish, install, test, and put into permanent operation a complete submarine cable system for the bridge as shown on the Plans and described herein.

2.0 SUBMITTALS

(A.) General Requirements

1. Prior to ordering the submarine cable, the Contractor shall review the submarine cable design with the Control Systems Vendor to verify that the cable has adequate conductors, cables, and spares for the control system requirements.
2. The contractor shall verify the exact length of cable required for the installation based upon his specific intended routing.

(B.) Required Information

1. Complete descriptive data (catalog cut sheets, etc.) for the overall submarine cables, as well as the component conductors and cables. Descriptive data shall clearly address all requirements given herein.

2. Cross section drawing. Drawing shall clearly identify the quantity and positions of the various component conductors and cables, inner and outer jacket thicknesses, armor wire sizes, outer diameter of the assembled cable, and approximate weight per foot of the overall cable.
3. Detailed procedures and drawings for the following:
 - a. Trench excavation.
 - b. Excavated material collection, storage, and disposal.
 - c. Cable installation.
 - d. Backfilling.
 - e. Locations of existing cables to be abandoned.
4. Testing procedures and results as required elsewhere in this section and these specifications
5. All required submittals must be approved by the Engineer prior to fabrication of, or purchase of materials for, the cables.

3.0 MATERIALS

(A.) General Requirements

1. Cables shall be designed and manufactured in accordance with ICEA S-95-658 (NEMA WC-70) and ICEA S-73-532 (NEMA WC-57).
2. Cables shall be specifically designed for underwater installation.
3. A minimum of 5 cables shall be provided. Each cable shall be continuous, and free of defects, splices, or repairs, from end to end.
4. Each cable shall contain the component conductors and cables as indicated on the Plans and/or the Contractor's approved shop drawings.
5. The component conductors and cables shall be individually labeled with printed legends consisting of numbers and words (e.g. 1-One, 2-Two, 3-Three, etc.). Labeling shall utilize color contrasting print, and remain legible after normal handling during installation.
6. All components shall be cabled into a tight concentric configuration. The direction of lay for adjacent layers shall be reversed. Non-hygroscopic fillers shall be included in the cable core as necessary to produce a substantially circular cross section. The bundled components shall be covered with a polyester binder tape, applied helically with a minimum 25% overlap.

7. The overall diameter of the cable over the outer jacket shall be not greater than 5 inches.
8. The cable manufacturer shall have been regularly and continuously engaged in the business of producing composite armored cables for underwater installation for a period of not less than 5 years as of the bid date. Recommended manufacturer is Draka USA. Other similarly qualified manufacturers may also be proposed.

(B.) Conductors and Cables

1. Conductors and cables shall be as described elsewhere in these Special Provisions. All submarine cable conductors and cables shall be rated for wet locations.

(C.) Armor

1. Galvanized steel wires, continuously coated with water and UV resistant high density polyethylene, per ICEA S-95-658. Minimum wire sizes and coating thicknesses shall be as follows:

<u>Calculated Diameter of Core Under Armor</u>	<u>Nominal Size of Wire Armor</u>	<u>Nominal Thickness of HDPE Coating</u>
0 to 0.75 inches	12 BWG	20 mils
0.751 to 1.000 inches	10 BWG	25 mils
1.001 to 1.700 inches	8 BWG	30 mils
1.701 to 2.500 inches	6 BWG	35 mils
2.501 + inches	4 BWG	40 mils

2. The coated armor wires shall be applied over the inner jacket at a lay angle of 17 to 25 degrees, and provide a minimum coverage of 92%. The armored layer shall be covered with a 2 mil corrugated polyester binder tape (25% minimum overlap), followed by a 2 mil adhesive polyester tape (25% minimum overlap).

(D.) Inner and Outer Jackets

1. Two jackets shall be provided: an inner jacket between the cable core and wire armor, and an outer jacket over the wire armor.
2. Each jacket shall be a continuous, homogeneous layer of water and UV resistant high density polyethylene per ICEA S-95-658. Minimum jacket thickness shall be as follows :

<u>Calculated Diameter of Cable Under Jacket</u>	<u>Average Jacket Thickness</u>
0 to 0.425 inches	45 mils
0.426 to 0.700 inches	60 mils
0.701 to 1.500 inches	80 mils
1.501 to 2.500 inches	110 mils

2.501 + inches

140 mils

(E.) Corrugated Duct

1. Flexible, corrugated polyethylene duct. One inch diameter.
2. Suitable for use in future installation of additional small cables/conductors after main cable installation.
3. With water and UV resistant synthetic pull rope pre-installed in the duct by the cable manufacturer.

(F.) Cable Packaging

1. Each cable shall be wound onto a suitable reel capable of supporting the weight of the cable during transportation and normal handling.
2. The ends of each cable shall be suitably sealed to prevent moisture ingress during shipment and storage.

4.0 INSTALLATION

(A.) General Requirements

1. The Contractor shall bear full responsibility for coordinating the installation of the submarine cables with the United States Army Corps of Engineers, the U.S. Coast Guard and all other federal, state, and/or local regulatory agencies having jurisdiction, all necessary permitting, and all costs associated therewith.
2. The underwater sections of the trenches shall be created by excavation of material from the river bottom. Excavation method must be approved by the Corps of Engineers.
3. All material excavated from the river bottom shall be disposed of off-site in an approved manner and in accordance with the requirements of the permit, and all applicable federal, state, and/or local laws and regulations. Any material designated as hazardous waste shall be disposed of at an approved hazardous waste site.
4. The Contractor shall bear full responsibility for all costs associated with handling, storage, transportation, and disposal of all excavated material. The Contractor shall provide to the Engineer documentation concerning the amount of material removed, hauling permits, hauling way bills, and disposal site records.
5. The submarine cable trenches shall be constructed in such a way as to avoid cave-ins during placement of the cables and backfill.
6. Bedding and Cable Placement

- a. The cables shall be placed in the trench and covered with bedding aggregate to a depth of at least 12 inches.
 - b. The remainder of the trench shall be filled with backfill aggregate to the elevation of the river bottom.
 - c. Bedding and Backfill Material: Bedding Aggregate: ASTM C33, Coarse Aggregate Table 2, Size #67; Backfill Aggregate: ASTM C33, Coarse Aggregate Table 2, Size #1.
7. The submarine cable depth shall be as directed by the Corps of Engineers; minimum 6 feet below elevation of channel bottom.
 8. The Contractor shall coordinate with the United States Coast Guard for any waterway closures needed to perform this work.

5.0 TESTING

(A.) General Requirements

1. Individual conductors shall be AC spark tested in accordance with ICEA S-95-658. Test voltage shall be as follows.

<u>Conductor Size</u>	<u>RMS AC Voltage</u>
14 AWG to 10 AWG	7.5 kV
8 AWG to 2 AWG	10.0 kV
1 AWG to 4/0 AWG	12.5 kV
225 kcmil to 500 kcmil	15.0 kV
Over 500 kcmil	17.5 kV

2. The insulation resistance of individual conductors in the finished cable shall be measured in accordance with ICEA S-73-532, S-95-658, and T-27-581. The minimum acceptable insulation resistance shall be determined in accordance with the following formula:

$$R = (IRK)\log_{10}(D/d)$$

Where: R = insulation resistance in megohms-1000 feet
IRK = insulation resistance constant (10,000 for XLPE)
D = diameter over the insulation
d = diameter under the insulation

3. The DC resistance of each individual conductor in the finished cable shall be measured. Measured resistance shall comply with ICEA S-73-532, S-95-658, and T-27-581.

4. The outer jacket of the finished cable shall be inspected for irregularity by AC spark testing in accordance with ICEA S-95-658 and T-27-581. The test shall be between the armor wires and the testing apparatus. Test voltage shall be as follows:

<u>Jacket Thickness</u>	<u>Voltage</u>
45 mils	4.0 kV
60 mils	5.5 kV
80 mils	7.0 kV
110 mils	10.0 kV
140 mils	12.5 kV

5. The shielded twisted pair cables, Ethernet, remote I/O, and fiber optic cable components shall be tested as described elsewhere in these Special Provisions.

6.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

TRAFFIC WARNING GATES AND TRAFFIC SIGNALS

1.0 DESCRIPTION

This section governs the installation of new traffic gates and traffic signals on the EB bridge and the replacement of the existing traffic gates on the WB bridge with new traffic gates, including all materials, labor, and equipment. Furnishing/installing gate anchorage in the median and removal of the existing gates is also included with the work of this item.

2.0 SUBMITTALS

(A.) General Requirements

1. Shop drawings of the EB and WB traffic gates, signals heads and mast arm poles shall be provided from the manufacturers. The drawings shall be signed and sealed by a registered engineer qualified to perform this work. Drawings shall be submitted to the Engineer for review.
2. Shop drawings shall include complete electrical specifications and wiring schematics.
3. The Contractor shall provide the manufacturers with accurate dimensions of the gate and pole mountings, railings, sidewalk, roadway. The contractor shall check the gate manufacturer's shop drawing mechanical dimensions to verify the supplied gates will operate properly with no mechanical interferences throughout the gate's range of operation.

3.0 MATERIALS

(A.) General Requirements

1. The gate operating mechanism housing shall be heavy duty weatherproof construction. All fasteners and hinges shall be corrosion resistant.
2. Housing doors shall be fully gasketed and shall have provisions for padlocking. Door safety limit switches shall be provided for disabling the gate control circuit in the event a door is opened.
3. A motor disconnect switch shall be provided in each gate operating mechanism housing. Terminal blocks shall be provided for landing all external wiring coming into the gate operator. Terminal blocks shall be numbered in accordance with full wiring diagrams provided by the manufacturer as part of shop drawing submittal.
4. A hand crank and manual brake release shall be furnished for emergency operation in the event of electrical failure. A dedicated hand crank safety switch shall prevent motor operation during hand crank operations.
5. Gate arm length and construction shall be as shown on the Plans.

4.0 INSTALLATION

(A.) General Requirements

1. Gates shall be installed as shown on the Plans. Gates shall be shimmed level, bolted in place, and grouted. Concrete anchors, where required, shall be Type 316 stainless steel adhesive type or wedge stud type.
2. Gates shall be adjusted so that gate arms in the fully lowered position are parallel with the roadway, and when in the fully raised position are vertical.
3. Provide and install 120 volt, 15 amp GFCI receptacles in the gate housings. Circuits are shown on the Plans.

5.0 TESTING

(A.) General Requirements

1. All gates and signals shall be tested for proper operation following installation. End of travel in both the raise and lower positions shall be adjusted as necessary. Gate limit switches shall be adjusted as necessary. Proper operation of each gate using the bridge control system shall be verified as shall all interlocking functions.

6.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

SUMP PUMP SYSTEMS

1.0 DESCRIPTION

This section governs the installation of new sump pumps on the EB bridge and the replacement of the existing sump pumps on the WB bridge with new sump pumps, including all materials, labor, and equipment.

2.0 SUBMITTALS

(A.) General Requirements

1. Detailed shop drawings of the pump installations shall be submitted to the Engineer for review. The drawings shall show all pipe fittings and the location of any electrical connections.
2. For the WB bridge, the drawings shall show any required field changes to the sump area to accommodate dual pump installation. Changes must be approved by the Engineer.

3.0 INSTALLATION

(A.) General Requirements

1. Electrical conductor splices near the pit floor elevation shall be avoided. If a splice near this area is required, a sealed splicing method approved for submersible applications shall be used, such as epoxy resin encapsulated splice kits by 3M Scotchcast.
2. Check valves shall be installed in each pump discharge line to prevent the backflow of water and to allow one pump to be removed without disabling the operation of the other pump.
3. Enlargement of existing sump areas shall be performed a neat manner. After any concrete has been removed, the resulting area shall be patched smooth and sealed with a waterproof grout material.

4.0 TESTING

(A.) General Requirements

1. The contractor is responsible for field testing the completed sump pump installation for each pit.
2. The testing shall verify the proper adjustment of all float switches, primary and backup pump operation, pump controller operation, and plumbing integrity.
3. If any leak is discovered, the contractor shall repair it and repeat the testing.

5.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL AND CONTROLS

1.0 DESCRIPTION

This Section covers the furnishing of all labor, material, equipment, devices and related appurtenances to perform the electrical rehabilitation of the existing Westbound bridge as shown on the contract plans and described below and in these Special Provisions.

The provisions and requirements of the following sections are hereby incorporated into this section by this reference, and shall have the same force and effect as if printed here in full:

- (A.) **Conduit and Wiring System**
- (B.) **Structure Grounding and Lightning Protection**
- (C.) **Bridge Control System**
- (D.) **Main Drives**
- (E.) **Traffic Warning Gates**
- (F.) **Sump Pump Systems**
- (G.) **Electrical Bridge Operation and Maintenance Manual**

2.0 CONSTRUCTION

(A.) General Requirements

1. All work shall be performed in a safe manner. Any electrical connections to the new bridge control system shall be carefully coordinated so as not to impact its normal operation and to insure the safety of workers.
2. Power feeds for motors, load panels, flux vector drives, and similar devices shall be properly locked and tagged out during construction.
3. All control and power wiring shall be tested before being connected to the new bridge control system. The Contractor shall coordinate the schedule for these connections with the Engineer, and the bridge control system operation shall be verified after any connections are made by the Contractor.
4. All temporary wiring that is energized shall be clearly identified as such.
5. Replacement of conduit and raceways shall include replacement of associated, junction boxes, conduit clamps, U-bolts and associated hardware.

3.0 REMOVALS

(A.) General Requirements

1. Unless a secondary use is approved by the Engineer, the existing raceways embedded in concrete shall be abandoned.
2. Existing raceways embedded in concrete which are to be abandoned in place shall have all conductors removed, be ground flush with the concrete, and filled with non-shrink grout. The locations and characteristics of all raceways, boxes, and equipment which are abandoned in place shall be clearly documented on the as-built drawings.

4.0 TESTING

(A.) General Requirements

1. The Contractor shall be responsible for performing all testing, inspections, and any resulting corrective work as may be necessary in order to ensure that all work is functioning properly, and as otherwise required elsewhere in these Special Provisions.
2. All testing shall be performed in a careful manner so as not to interfere with the normal operation of the new EB bridge.
3. If testing could potentially interfere with the normal operation of the new EB bridge, it shall be coordinated with and approved by the Engineer.

5.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

ELECTRICAL BRIDGE OPERATION AND MAINTENANCE MANUAL

1.0 DESCRIPTION

Provide preliminary and final versions of the Electrical Operation and Maintenance manual for bridge electrical work, including all systems, equipment, and materials.

2.0 MATERIALS

(A.) Manual

1. Binder shall be hardback vinyl three ring loose leaf-type of one solid color. Binder spine and front shall display labels containing the name of the bridge location, the name of the contractor and dates of the work.
2. The binder holes shall be reinforced for all contents. The paper and ink shall resist smearing, fading and deterioration from age.

(B.) Chapters

1. Chapter 1 will be designated for general information and safety precautions. Information from the department's safety manual shall be included as applicable.

2. Chapter 2 will be designated to supply all utility information including the following:
 - a. Incoming electrical power information including contact information, service designations, location plans, and all utility information for the new commercial service as defined elsewhere in these Special Provisions.
 - b. Water and sewer utility information including contact information and plans showing the location of utility connections and shutoffs.
 - c. Phone and cable TV utility information including contact information and plans showing the location of utility connections.
3. Chapter 3 shall contain a bridge operation manual. The chapter shall be written in such a manner that could be used a training tool for new bridge operators. It shall include detailed written normal bridge operating sequences and operator procedures for automatic and manual control modes. Drawings and color photographs of the control consoles shall be used to illustrate locations and functions of pushbuttons, control switches, and indicator lights. A detailed alarm listing, alphanumeric message listing, and corresponding operator level troubleshooting steps shall be included.
4. Chapter 4 shall consist of troubleshooting diagrams (fault isolation trees) and/or procedures to be used by maintenance personnel for isolating faults to the lowest reparable limit level. It shall include touchscreen display information including screen menu structures and actual screen captures (in color) to illustrate the features and functions available from the touchscreen. Detailed information shall also be provided to train maintenance personnel on the data collection information available for troubleshooting. Any periodic maintenance schedule items are to be included with recommended maintenance intervals.
5. Chapter 5 shall include the complete PLC program listing as defined elsewhere in these Special Provisions. Tabs shall be inserted in the PLC program listing to identify major sections of logic that are specific to the EB and WB bridges
6. Chapter 6 shall include the message listings and hardware/software configuration settings of the alphanumeric display.
7. Chapter 7 shall include the parameter listings for each flux vector drive. Any other specific drive configuration is to be supplied including hardware switch settings. Tabs shall be inserted to identify the EB and WB drives. Any training material from the drive manufacturer shall be included in this chapter.
8. Chapter 8 shall include the product information for the major control system components. This shall include product manuals for all PLC equipment and all enclosure related equipment, all console related equipment, and all flux vector drive

equipment. Any software product manuals and license information shall be included.

9. Chapter 9 shall include electrical product information not included in Chapter 8. The as-built version of the electrical equipment list shown in the Plans shall be used as a guide for ordering the product information within the chapter. The Chapter index shall identify any items used exclusively on the EB or WB bridge.
10. Chapter 10 shall include half-size prints of "as-built" contract and shop drawings. The prints shall be folded to fit into the manual
11. Chapter 11 shall include the duration and contents of all guarantees and warranties.

(C.) Content Requirements

1. Each binder shall have a neatly typewritten index near the front of the manual. The first manual shall have an additional index that shall list the content of each manual.
2. Vendors and suppliers listing shall include names, addresses and telephone numbers. Internet web site information shall be included when available.
3. Where the contents of the manuals include manufacturer's catalog pages, clearly indicate the precise items included in this installation and delete all manufacturer's data with which this installation is not concerned.
4. All material within the manuals shall be new. Copies used for prior submittals or used in construction of the project are not acceptable.
5. Manuals shall have index tabs for fast and easy reference to equipment and material. Tabs shall index each piece of equipment and systems.

(D.) Construction

1. Make a preliminary manual submittal of two copies to the engineer for review and approval; make a submittal of final manuals in three copies to the engineer.
2. Submittal of preliminary and final manual editions shall be furnished to the Engineer according to the approved official progress schedule.
3. Preliminary manual editions shall present all technical material for the electrical volume to the greatest extent possible with respect to text, tabular matter, and illustrations. Illustrations shall preferably consist of line drawings. (Sketches or photographs may be used if final drawings are unavailable at the time of submittal.) All applicable shop drawings shall be included.
4. Final manual editions shall be technically accurate and complete and shall represent the "as-built" system, piece of equipment, or material given final acceptance by the

engineer. All illustrations, text, and tabular material shall be in final form; all shop drawings shall be included.

3.0 MEASUREMENT AND PAYMENT

Work covered by this section is an integral part of Item NEW EASTBOUND BRIDGE ELECTRICAL WORK and Item REHABILITATION OF WESTBOUND BRIDGE ELECTRICAL WORK. No separate measurement or payment will be made.

APPENDIX A

**DETAILED CONTROL
HOUSE SPECIFICATIONS**

NOTE: Reference to a specific manufacturer, brand, model or catalog number is intended to describe the quality and characteristics of the item or material referenced, and shall not be interpreted as excluding equivalent products by other manufacturers. All proposed substitutions shall be submitted to the Engineer for approval.

SECTION 05 12 00 – STRUCTURAL STEEL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as though bound herein.

1.02 SUMMARY

- A. This Section includes fabrication and erection of structural steel work, as shown on drawings including schedules, notes, and details showing size and location of members, typical connections, and types of steel required.
- B. Structural steel is that work defined in American Institute of Steel Construction (AISC) "Code of Standard Practice" and as otherwise shown on drawings.
- C. Miscellaneous Metal Fabrications are specified elsewhere in Division 5.
- D. Refer to Division 3 for anchor bolt installation in concrete, Division 4 for anchor bolt installation in masonry.

1.03 WORK INCLUDED

- A. Structural steel framing members, structural steel support members, sag rods which form a part of structural framing complete with required bracing, welds, washers, nuts, shims, bolts and anchor bolts.
- B. Base plates and bearing plates.
- C. Erection and connecting structural steel frame.
- D. Grouting under base plates and bearing plates.
- E. Reinforcing openings in metal decks larger than 12 inches in size.

1.04 REFERENCES

- A. ASTM A992: Structural Steel.
- B. ASTM A307: Carbon Steel Externally Threaded Standard Fasteners.
- C. ASTM A325: High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain hardened Washers.
- D. ASTM A490: Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints.
- E. ASTM A500: Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in

Rounds and Shapes.

- F. AWS D1.1: Structural Welding Code.
- G. AISC "Code of Standard Practice for Steel Buildings and Bridges" and Commentary.
- H. AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" and including the "Commentary" and Supplements thereto.
- I. AISC "Specification for Structural Joints using ASTM A325 or A490 Bolts."
- J. SSPC SP2: Surface Preparation Specification No. 2 - Hand Tool Cleaning.
- K. SSPC SP3: Surface preparation Specification No. 3 - Power Tool Cleaning.

1.05 SUBMITTALS

- A. Product data or manufacturer's specifications and installation instructions for following products. Include laboratory test reports and other data to show compliance with specifications (including specified standards).
- B. Structural steel (each type), including certified copies of mill reports covering chemical and physical properties.
 - 1. High-strength bolts (each type), including nuts and washers.
 - 2. Structural steel primer paint.
 - 3. Shrinkage-resistant grout.
- C. Shop drawings prepared under supervision of a licensed Structural Engineer, including complete details and schedules for fabrication and assembly of structural steel members, procedures, and diagrams. All shop drawings and calculations shall be signed and sealed by the structural engineer.
- D. Include details of cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols and show size, length, and type of each weld.
- E. Provide setting drawings, templates, and directions for installation of anchor bolts and other anchorages to be installed as work of other sections.
- F. Test reports conducted on shop- and field-bolted and welded connections. Include data on type(s) of tests conducted and test results.

1.06 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of following, except as otherwise indicated:
- B. American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges."
 - 1. AISC Code of Standard practice. Make the following modifications:
 - a. Delete Paragraph 3.3. Substitute the following: All things which, in the opinion of the

Contractor, appear to be deficiencies, omissions, contradictions or ambiguities in the Contract Documents shall be brought to the attention of the Architect. The Contract Documents will be corrected or a contradiction or ambiguity will be made by the Architect before the effected work proceeds.

- C. AISC "Specifications for Structural Steel Buildings," including "Commentary."
- D. "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" approved by the Research Council on Structural Connections.
- E. American Welding Society (AWS) D1.1 "Structural Welding Code -Steel."
- F. ASTM A 6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use."
- G. **Installer Qualifications:** Engage an experienced Installer who has completed structural steel work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- H. **Fabricator Qualifications:** Engage a firm experienced in fabricating structural steel similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to fabricate structural steel without delaying the Work. Fabricator must participate in the AISC Quality Certification Program and be designated an AISC-Certified Plant as follows: Category: Category I, conventional steel structures.
- I. **Structural Performance:** Engineer structural steel connections required by the Contract Documents to be selected or completed by the fabricator to withstand design loadings indicated.
- J. **Engineering Responsibility:** Engage a fabricator who utilizes a qualified professional engineer to prepare calculations, Shop Drawings, and other structural data for structural steel connections.
- K. **Qualifications for Welding Work:** Qualify welding procedures and welding operators in accordance with AWS "Qualification" requirements.
 - 1. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests.
 - 2. If re-certification of welders is required, retesting will be Contractor's responsibility.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to site at such intervals to ensure uninterrupted progress of work.
- B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete or masonry, in ample time to not to delay work.
- C. Store materials to permit easy access for inspection and identification. Keep steel members off ground by using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration. If bolts and nuts become dry or rusty, clean and

relubricate before use.

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

PART 2 - PRODUCTS

2.01 MATERIALS

- A. **Metal Surfaces, General:** For fabrication of work that will be exposed to view, use only materials that are smooth and free of surface blemishes including pitting, rust and scale seam marks, roller marks, rolled trade names, and roughness. Remove such blemishes by grinding, or by welding and grinding, prior to cleaning, treating, and applying surface finishes.
- B. **Structural Steel Shapes, Plates, and Bars:** ASTM A 992.
- C. **Cold-Formed Steel Tubing:** ASTM A 500, Grade B.
- D. **Hot-Formed Steel Tubing:** ASTM A 501.
- E. **Steel Pipe:** ASTM A 53, Type E or S, Grade B; or ASTM A 501.
- F. **Finish:** Primed, except where indicated to be galvanized.
- G. **Steel Castings:** ASTM A 27, Grade 65-35, medium-strength carbon steel.
- H. **Anchor Bolts:** ASTM A 307, nonheaded type unless otherwise indicated.
- I. **Unfinished Threaded Fasteners:** ASTM A 307, Grade A, regular low-carbon steel bolts and nuts.
 - 1. Provide either hexagonal or square heads and nuts, except use only hexagonal units for exposed connections.
 - 2. **High-Strength Threaded Fasteners:** Heavy hexagon structural bolts, heavy hexagon nuts, and hardened washers, as follows:
 - 3. Quenched and tempered medium-carbon steel bolts, nuts, and washers, complying with ASTM A 325.
 - 4. Where indicated as galvanized, provide units that are zinc coated, either mechanically deposited complying with ASTM B 695, Class 50, or hot-dip galvanized complying with ASTM A 153.
- J. **Electrodes for Welding:** Comply with AWS Code.
- K. **Structural Steel Primer Paint:** SSPC - Paint 13.
- L. **Cement Grout:** Portland cement (ASTM C 150, Type I or Type III) and clean, uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum water required for placement and hydration.

- M. **Nonmetallic Shrinkage-Resistant Grout:** Premixed, nonmetallic, noncorrosive, nonstaining product containing selected silica sands, Portland cement, shrinkage compensating agents, plasticizing and water-reducing agents, complying with CE-CRD-C621.
- N. **Products:** Subject to compliance with requirements, provide one of the following:
- Sure Grip Grout; Dayton Superior.
 - Euco N.S.; Euclid Chemical Co.
 - Crystex; L & M Construction Chemicals, Inc.
 - Masterflow 713; Master Builders.
 - Sealtight 588 Grout; W. R. Meadows.
 - Five Star Grout; U.S. Grout Corp.
 - Enduro #50; Conspec Marketing & Manufacturing Co.

2.02 FABRICATION

- A. **Shop Fabrication and Assembly:** Fabricate and assemble structural assemblies in shop to greatest extent possible. Fabricate items of structural steel in accordance with AISC Specifications and as indicated on final shop drawings. Provide camber in structural members where indicated.
- B. Properly mark and match-mark materials for field assembly. Fabricate for delivery sequence that will expedite erection and minimize field handling of materials.
- C. Where finishing is required, complete assembly, including welding of units, before start of finishing operations. Provide finish surfaces of members exposed in final structure free of markings, burrs, and other defects.
- D. **Connections:** Weld or bolt shop connections, as indicated.
1. Bolt field connections, except where welded connections or other connections are indicated.
 2. Provide high-strength threaded fasteners for principal bolted connections, except where unfinished bolts are indicated.
- E. **High-Strength Bolted Construction:** Install high-strength threaded fasteners in accordance with AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts."
- F. **Welded Construction:** Comply with AWS Code for procedures, appearance and quality of welds, and methods used in correcting welding work.
- G. Assemble and weld built-up sections by methods that will produce true alignment of axes without warp.
- H. **Steel Wall Framing:** Select members that are true and straight for fabrication of steel wall framing. Straighten as required to provide uniform, square, and true members in completed wall framing.
- I. Build up welded door frames attached to structural steel framing. Weld exposed joints continuously and grind smooth. Plug-weld steel bar stops to frames, except where shown removable. Secure removable stops to frames with countersunk, cross-recessed head machine

screws, uniformly spaced not more than 10 inches o.c., unless otherwise indicated.

- J. Holes for Other Work: Provide holes required for securing other work to structural steel framing and for passage of other work through steel framing members, as shown on final shop drawings.
- K. Provide threaded nuts welded to framing and other specialty items as indicated to receive other work.
- L. Cut, drill, or punch holes perpendicular to metal surfaces. Do not flame-cut holes or enlarge holes by burning. Drill holes in bearing plates.
- M. Expansion Joints: Provide expansion joints in steel shelf angles when part of structural steel frame; locate at vertical brick expansion joints as indicated on drawings.

2.03 PAINTING

- A. General: Shop-paint structural steel, except those members or portions of members to be embedded in concrete or mortar. Paint embedded steel that is partially exposed on exposed portions and initial 2 inches of embedded areas only.
- B. Do not paint surfaces to be welded or high-strength bolted with friction-type connections.
- C. Do not paint surfaces scheduled to receive sprayed-on fireproofing.
- D. Apply 2 coats of paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.
- E. Surface Preparation: After inspection and before shipping, clean steel Work to be painted. Remove loose rust, loose mill scale, and spatter, slag, or flux deposits. Clean steel in accordance with Steel Structures Painting Council (SSPC) as follows:
- F. SP-3 "Power-Tool Cleaning."
- G. Painting: Provide a one-coat, shop-applied paint system complying with Steel Structures Painting Council (SSPC) Paint System Guide No. 7.00.

2.04 SOURCE QUALITY CONTROL

- A. General: Materials and fabrication procedures are subject to inspection and tests in mill, shop, and field, conducted by a qualified inspection agency. Such inspections and tests will not relieve Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
- B. Promptly remove and replace materials or fabricated components that do not comply.
- C. Engineer's Design of Members and Connections: Details shown are typical; similar details apply to similar conditions, unless otherwise indicated. Verify dimensions at site whenever possible without causing delay in the work.

- D. Promptly notify Architect whenever design of members and connections for any portion of structure are not clearly indicated.

PART 3 - EXECUTION

3.01 ERECTION

- A. **Temporary Shoring and Bracing:** Provide temporary shoring and bracing members with connections of sufficient strength to bear imposed loads. Remove temporary members and connections when permanent members are in place and final connections are made. Provide temporary guy lines to achieve proper alignment of structures as erection proceeds.
- B. **Temporary Planking:** Provide temporary planking and working platforms as necessary to effectively complete work.
- C. **Setting Bases and Bearing Plates:** Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of base and bearing plates.
 - 1. Set loose and attached base plates and bearing plates for structural members on wedges or other adjusting devices.
 - 2. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to packing with grout.
 - 3. Pack grout solidly between bearing surfaces and bases or plates to ensure that no voids remain. Finish exposed surfaces, protect installed materials, and allow to cure.
 - 4. For proprietary grout materials, comply with manufacturer's instructions.
- A. **Field Assembly:** Set structural frames accurately to lines and elevations indicated. Align and adjust various members forming part of complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
- B. **Openings:** Provide framing as needed around openings through roof structure.
- C. **Level and plumb individual members of structure within specified AISC tolerances.**
- D. **Splice members only where indicated and accepted on shop drawings.**
- E. **Erection Bolts:** On exposed welded construction, remove erection bolts, fill holes with plug welds, and grind smooth at exposed surfaces.
- F. **Comply with AISC Specifications for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.**
- G. **Do not enlarge unfair holes in members by burning or by using drift pins, except in secondary**

bracing members. Ream holes that must be enlarged to admit bolts.

- H. **Gas Cutting:** Do not use gas cutting torches in field for correcting fabrication errors in primary structural framing. Cutting will be permitted only on secondary members that are not under stress, as acceptable to Architect. Finish gas-cut sections equal to a sheared appearance when permitted.
- I. **Touch-Up Painting:** Cleaning and touch-up painting of field welds, bolted connections, and abraded areas of shop paint on structural steel is included in Division 9 under painting work.

3.02 QUALITY CONTROL

- A. Owner will engage an independent testing and inspection agency to inspect high-strength bolted connections and welded connections and to perform tests and prepare test reports.
- B. Testing agency shall conduct and interpret tests, state in each report whether test specimens comply with requirements, and specifically state any deviations therefrom.
- C. Provide access for testing agency to places where structural steel work is being fabricated or produced so that required inspection and testing can be accomplished.
- D. Testing agency may inspect structural steel at plant before shipment.
- E. Correct deficiencies in structural steel work that inspections and laboratory test reports have indicated to be not in compliance with requirements. Perform additional tests, at Contractor's expense, as necessary to reconfirm any noncompliance of original work and to show compliance of corrected work.
- F. **Shop Welding:** Inspect and test during fabrication of structural steel assemblies, as follows:
 - 1. Certify welders and conduct inspections and tests as required. Record types and locations of defects found in work. Record work required and performed to correct deficiencies.
 - 2. Perform visual inspection of all welds.

END OF SECTION 05 12 00

SECTION 05 31 00 – STEEL DECK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as though bound herein.

1.02 SUMMARY

- A. The Work of this Section consists of providing all metal decking and related items necessary to complete the Work indicated on the Drawings and specified herein as follows:
 - 1. Metal roof deck units

1.03 WORK INCLUDED

- A. Miscellaneous steel not indicated on the Drawings but required to support metal deck.
- B. Cutting of holes and openings in metal deck.
- C. Touch-up painting

1.04 REFERENCES

- A. Steel Deck Institute: Design manual for Composite Decks, Form Decks and Roof Decks.
- B. ASTM A446: Steel Sheet, Galvanised, Structural Quality.
- C. ASTM A525: Steel Sheet, Galvanised, General Requirements.
- D. ASTM A611: Steel, Cold-Rolled Sheet, Carbon, Structural.
- E. AISC: Specification for the Design of Cold-Formed Steel Structural Members.
- F. AWS D1.1: Structural Welding Code.

1.05 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
 - 1. Shop drawings showing layout and types of deck units, anchorage details, and conditions requiring closure strips, supplementary framing, cut openings, special jointing, and other accessories.

1.06 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of the following codes and standards, except as otherwise indicated:
 - 1. American Iron and Steel Institute (AISI), "Specification for the Design of Cold-Formed Steel Structural Members."
 - 2. American Welding Society (AWS), D1.3 "Structural Welding Code - Sheet Steel."
 - 3. Steel Deck Institute (SDI), "Design Manual for Composite Decks, Form Decks and Roof Decks."
- B. Qualification of Field Welding: Use qualified welding processes and welding operators in accordance with "Welder Qualification" procedures of AWS
- C. FM Listing: Provide steel roof deck units that have been evaluated by Factory Mutual System and are listed in "Factory Mutual Approval Guide" for "Class I" fire-rated construction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products of one of the following:
 - Bowman Metal Deck Div., Cyclops Corp.
 - Consolidated Systems, Inc.
 - Epic Metals Corp.
 - Marlyn Steel Products, Inc.
 - H. H. Robertson Co.
 - Roll Form Products, Inc.
 - Roof Deck, Inc.
 - United Steel Deck, Inc.
 - Vulcraft Div., Nucor Corp.
 - Wheeling Corrugating Co.
- B. Steel roof deck shall be 1.0" 20 gauge galvanized roof deck, type "E", by Vulcraft 1.0E20 or better.

2.02 MATERIALS

- A. Steel for Galvanized Metal Deck Units: ASTM A 446, grade as required to comply with SDI specifications.
- B. Miscellaneous Steel Shapes: ASTM A 572.
- C. Sheet Metal Accessories: ASTM A 526, commercial quality, galvanized.
 - 1. Galvanizing: ASTM A 525, G60.
 - 2. Galvanizing Repair: Where galvanized surfaces are damaged, prepare surfaces and repair in accordance with procedures specified in ASTM A 780.

2.03 FABRICATION

- A. **General:** Form deck units in lengths to span three or more supports, with flush, telescoped, or nested 2-inch laps at ends and interlocking or nested side laps, of metal thickness, depth, and width as indicated.
- B. **Metal Closure Strips:** Fabricate metal closure strips, for cell raceways and openings between decking and other construction, of not less than 0.045-inch min. (18 gage) sheet steel. Form to provide tight-fitting closures at open ends of cells or flutes and sides of decking.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. **General:** Install deck units and accessories in accordance with manufacturer's recommendations, shop drawings, and as specified herein.
 - 1. Place deck units on supporting steel framework and adjust to final position with ends accurately aligned and bearing on supporting members before being permanently fastened. Do not stretch or contract side lap interlocks.
 - 2. Align deck units for entire length of run of cells and with close alignment between cells at ends of abutting units.
 - 3. Place deck units flat and square, secured to adjacent framing without warp or deflection.
 - 4. Do not place deck units on concrete supporting structure until concrete has cured and is dry.
 - 5. Coordinate and cooperate with structural steel erector in locating decking bundles to prevent overloading of structural members.
 - 6. Do not use floor deck units for storage or working platforms until permanently secured.
- B. **Fastening Metal Roof Deck:**
 - 1. Mechanical fasteners, either powder-actuated or pneumatically driven driven or No. 12 machine screw fasteners shall be used. Locate mechanical fasteners and install in accordance with deck manufacturer's instructions.
 - 2. Fasten deck to supporting members in a 36/4 pattern.
 - 3. Mechanically fasten side laps of adjacent deck units between supports, at intervals not exceeding 36 inches o.c. minimum of 2 fasteners per span, using self-tapping No. 10 or larger machine screws.
- C. **Cutting and Fitting:** Cut and neatly fit deck units and accessories around other work projecting through or adjacent to the decking, as shown.
- D. **Reinforcement at Openings:** Provide additional metal reinforcement and closure pieces as required for strength, continuity of decking, and support of other work shown.
- E. **Joint Covers:** Provide metal joint covers at abutting ends and changes in direction of floor deck units, except where taped joints are required.
- F. **Closure Strips:** Provide metal closure strips at open uncovered ends and edges of decking and in voids between decking and other construction. Weld into position to provide a complete decking installation.

- G. **Touch-Up Painting:** After decking installation, wire brush, clean, and paint scarred areas, welds, and rust spots on top and bottom surfaces of decking units and supporting steel members.
 - 1. Touch-up galvanized surfaces with galvanizing repair paint applied in accordance with manufacturer's instructions.

END OF SECTION 05 31 00

SECTION 05 40 00 - COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.**

1.2 SUMMARY

- A. This Section includes the following:**
- 1. Exterior non-load-bearing wall framing.**
 - 2. Roof trusses.**
 - 3. Ceiling joist framing.**
- B. Related Sections include the following:**
- 1. Division 05 Section "Metal Fabrications" for masonry shelf angles and connections.**
 - 2. Division 09 Section "Non-Structural Metal Framing" for interior non-load-bearing, metal-stud framing and ceiling-suspension assemblies.**
 - 3. Division 09 Section "Gypsum Board Shaft Wall Assemblies" for interior non-load-bearing, metal-stud-framed, shaft-wall assemblies.**

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide cold-formed metal framing capable of withstanding design loads within limits and under conditions indicated.**
- 1. Design Loads: As indicated.**
 - 2. Deflection Limits: Design framing systems to withstand design loads without deflections greater than the following:**
 - a. Interior Non-Load-Bearing Wall Framing: Horizontal deflection of 1/240 of the wall height under a horizontal load of 5 lbf/sq. ft.**
 - b. Exterior Non-Load-Bearing Framing: Horizontal deflection of 1/240 of the wall height.**
 - c. Roof Trusses: Vertical deflection of 1/240 of the span.**
 - d. Ceiling Joist Framing: Vertical deflection of 1/240 of the span.**
 - 3. Design framing systems to provide for movement of framing members without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 120 deg F.**
 - 4. Design framing system to maintain clearances at openings, to allow for construction tolerances.**
- B. Cold-Formed Steel Framing, General: Design according to AISI's "Standard for Cold-Formed Steel Framing - General Provisions."**

1. Headers: Design according to AISI's "Standard for Cold-Formed Steel Framing - Header Design."
2. Design exterior non-load-bearing wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.
3. Roof Trusses: Design according to AISI's "Standard for Cold-Formed Steel Framing - Truss Design."

1.4 SUBMITTALS

- A. Product Data: For each type of cold-formed metal framing product and accessory indicated.
- B. Shop Drawings: Show layout, spacings, sizes, thicknesses, and types of cold-formed metal framing; fabrication; and fastening and anchorage details, including mechanical fasteners. Show reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.
 1. For cold-formed metal framing indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- C. Welding certificates.
- D. Product Test Reports: From a qualified testing agency, unless otherwise stated, indicating that each of the following complies with requirements, based on evaluation of comprehensive tests for current products:
 1. Steel sheet.
 2. Expansion anchors.
 3. Power-actuated anchors.
 4. Mechanical fasteners.
 5. Vertical deflection clips.
 6. Horizontal drift deflection clips
 7. Miscellaneous structural clips and accessories.
- E. Research/Evaluation Reports: For cold-formed metal framing.

1.5 QUALITY ASSURANCE

- A. Engineering Responsibility: Preparation of Shop Drawings, design calculations, and other structural data by a qualified professional engineer.
- B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of cold-formed metal framing that are similar to those indicated for this Project in material, design, and extent.
- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM E 329 to conduct the testing indicated.

- D. **Product Tests:** Mill certificates or data from a qualified independent testing agency indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements and metallic-coating thickness.
- E. **Welding:** Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."
- F. **Fire-Test-Response Characteristics:** Where indicated, provide cold-formed metal framing identical to that of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
- G. **AISI Specifications and Standards:** Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" and its "Standard for Cold-Formed Steel Framing - General Provisions."
 - 1. Comply with AISI's "Standard for Cold-Formed Steel Framing - Truss Design."
 - 2. Comply with AISI's "Standard for Cold-Formed Steel Framing - Header Design."
- H. **Preinstallation Conference:** Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. **Protect cold-formed metal framing from corrosion, deformation, and other damage during delivery, storage, and handling.**
- B. **Store cold-formed metal framing, protect with a waterproof covering, and ventilate to avoid condensation.**

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering cold-formed metal framing that may be incorporated into the Work include, but are not limited to, the following:
- B. **Manufacturers:** Subject to compliance with requirements, provide cold-formed metal framing by one of the following:
 - 1. Allied Studco.
 - 2. AllSteel Products, Inc.
 - 3. California Expanded Metal Products Company.
 - 4. Clark Steel Framing.
 - 5. Consolidated Fabricators Corp.; Building Products Division.
 - 6. Craco Metals Manufacturing, LLC.
 - 7. Custom Stud, Inc.
 - 8. Dale/Incor.
 - 9. Design Shapes in Steel.
 - 10. Dietrich Metal Framing; a Worthington Industries Company.

11. Formetal Co. Inc. (The).
12. Innovative Steel Systems.
13. MarinoWare; a division of Ware Industries.
14. Quail Run Building Materials, Inc.
15. SCAFCO Corporation.
16. Southeastern Stud & Components, Inc.
17. Steel Construction Systems.
18. Steeler, Inc.
19. Super Stud Building Products, Inc.
20. United Metal Products, Inc.

2.2 MATERIALS

- A. **Recycled Content of Steel Products:** Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
- B. **Steel Sheet:** ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of grade and coating weight as follows:
 1. **Grade:** As required by structural performance.
 2. **Coating:** G60 or equivalent.

2.3 EXTERIOR NON-LOAD-BEARING WALL FRAMING

- A. **Steel Studs:** Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
 1. **Minimum Base-Metal Thickness:** 0.0428 inch.
 2. **Flange Width:** 1-3/8 inches.
 3. **Section Properties:** Minimum strong axis section modulus 0.772 in. cubed, minimum strong axis moment of inertia shall be 0.2.316 in. to fourth and an allowable moment of 16,764 in-lbs.
- B. **Steel Track:** Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:
 1. **Minimum Base-Metal Thickness:** Matching steel studs.
 2. **Flange Width:** 1-1/4 inches.

2.4 THIS SECTION INTENTIONALLY LEFT BLANK

2.5 CEILING JOIST FRAMING

- A. **Steel Ceiling Joists:** Manufacturer's standard C-shaped steel sections, of web depths indicated with stiffened flanges, and as follows:
 - 1. **Minimum Base-Metal Thickness:** 0.0428 inch.
 - 2. **Flange Width:** 1-5/8 inches minimum.
 - 3. **Section Properties:** As required to satisfy loading.

2.6 FRAMING ACCESSORIES

- A. **Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.**
- B. **Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:**
 - 1. **Supplementary framing.**
 - 2. **Bracing, bridging, and solid blocking.**
 - 3. **Web stiffeners.**
 - 4. **Anchor clips.**
 - 5. **End clips.**
 - 6. **Foundation clips.**
 - 7. **Gusset plates.**
 - 8. **Stud kickers, knee braces, and girts.**
 - 9. **Joist hangers and end closures.**
 - 10. **Hole reinforcing plates.**
 - 11. **Backer plates.**

2.7 ANCHORS, CLIPS, AND FASTENERS

- A. **Steel Shapes and Clips:** ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.
- B. **Anchor Bolts:** ASTM F 1554, Grade 36, threaded carbon-steel headless bolts, with nut on encased end and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C.
- C. **Expansion Anchors:** Fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 5 times design load, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
- D. **Power-Actuated Anchors:** Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 10 times design load, as determined by testing per ASTM E 1190 conducted by a qualified independent testing agency.
- E. **Mechanical Fasteners:** ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping steel drill screws.
 - 1. **Head Type:** Low-profile head beneath sheathing, manufacturer's standard elsewhere.

- F. Welding Electrodes: Comply with AWS standards.

2.8 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: SSPC-Paint 20 or DOD-P-21035.
- B. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- C. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents, complying with ASTM C 1107, with fluid consistency and 30-minute working time.
- D. Shims: Load bearing, high-density multimonomer plastic, nonleaching.
- E. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch thick, selected from manufacturer's standard widths to match width of bottom track or rim track members.

2.9 FABRICATION

- A. Fabricate cold-formed metal framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.
 - 1. Fabricate framing assemblies using jigs or templates.
 - 2. Cut framing members by sawing or shearing; do not torch cut.
 - 3. Fasten cold-formed metal framing members by welding, screw fastening, clinch fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
 - a. Comply with AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - b. Locate mechanical fasteners and install according to Shop Drawings, with screw penetrating joined members by not less than three exposed screw threads.
 - 4. Fasten other materials to cold-formed metal framing by welding, bolting, or screw fastening, according to Shop Drawings.
- B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.
- C. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - 1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
 - 2. Squareness: Fabricate each cold-formed metal framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine supporting substrates and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance.**
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.**

3.2 PREPARATION

- A. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.**
- B. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that are required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.**
- C. Install load bearing shims or grout between the underside of wall bottom track or rim track and the top of foundation wall or slab at stud or joist locations to ensure a uniform bearing surface on supporting concrete or masonry construction.**
- D. Install sealer gaskets to isolate the underside of wall bottom track or rim track and the top of foundation wall or slab at stud or joist locations.**

3.3 INSTALLATION, GENERAL

- A. Cold-formed metal framing may be shop or field fabricated for installation, or it may be field assembled.**
- B. Install cold-formed metal framing according to AISI's "Standard for Cold-Formed Steel Framing - General Provisions" and to manufacturer's written instructions unless more stringent requirements are indicated.**
- C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.**
 - 1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch.**
- D. Install cold-formed metal framing and accessories plumb, square, and true to line, and with connections securely fastened.**
 - 1. Cut framing members by sawing or shearing; do not torch cut.**
 - 2. Fasten cold-formed metal framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.**
 - a. Comply with AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.**

- b. Locate mechanical fasteners and install according to Shop Drawings, and complying with requirements for spacing, edge distances, and screw penetration.
- E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- F. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- G. Do not bridge building expansion and control joints with cold-formed metal framing. Independently frame both sides of joints.
- H. Install insulation, specified in Division 07 Section "Thermal Insulation," in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- I. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's standard punched openings.
- J. Erection Tolerances: Install cold-formed metal framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - 1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.4 EXTERIOR NON-LOAD-BEARING WALL INSTALLATION

- A. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure as indicated.
- B. Fasten both flanges of studs to top and bottom track, unless otherwise indicated. Space studs as follows:
 - 1. Stud Spacing: 16 inches or as indicated.
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.
- D. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
 - 1. Install single-leg deflection tracks and anchor to building structure.
 - 2. Install double deep-leg deflection tracks and anchor outer track to building structure.
 - 3. Connect vertical deflection clips to infill studs and anchor to building structure.
- E. Install horizontal bridging in wall studs, spaced in rows indicated on Shop Drawings but not more than 48 inches apart. Fasten at each stud intersection.
 - 1. Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs.

- F. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, fasteners, and stud girts, to provide a complete and stable wall-framing system.

3.5 TRUSS INSTALLATION

- A. Install, bridge, and brace trusses according to Shop Drawings and requirements in this Section.
- B. Truss Spacing: As indicated with a maximum spacing of 48 inches.
- C. Do not alter, cut, or remove framing members or connections of trusses.
- D. Erect trusses with plane of truss webs plumb and parallel to each other, align, and accurately position at spacings indicated.
- E. Erect trusses without damaging framing members or connections.
- F. Align webs of bottom chords and load-bearing studs or continuously reinforce track to transfer loads to structure. Anchor trusses securely at all bearing points.
- G. Install continuous bridging and permanently brace trusses as indicated on Shop Drawings and designed according to LGSEA's Technical Note 551e, "Design Guide for Permanent Bracing of Cold-Formed Steel Trusses."

3.6 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Field and shop welds will be subject to testing and inspecting.
- C. Testing agency will report test results promptly and in writing to Contractor and Architect.
- D. Remove and replace work where test results indicate that it does not comply with specified requirements.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.7 REPAIRS AND PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed metal framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed metal framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION 054000

SECTION 054500 - PRE-ENGINEERED LIGHT GAUGE STEEL TRUSSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as though bound herein.

1.2 SUMMARY

- A. Section includes the Work required to complete the installation of the pre-engineered light gauge roof trusses as shown on the drawings and specified herein, including headers, outriggers, supplemental rafters and incidental framing for a complete assembly within the extent shown on the drawings.

1.3 RELATED WORK

- A. Structural Steel: Section 05100
- B. Roof Deck: Section 05310
- C. Curbs, Wood Nailers & Other Rough Carpentry: Section 06100

1.4 REFERENCE STANDARDS

- A. American Iron and Steel Institute: Specification for the Design of Cold-Formed Steel Structural Members.
- B. American Society of Testing Materials:
1. ASTM A 446: "Specification for Sheet Steel, Zinc Coated (Galvanized) by the Hot-Dip Process, Physical (Structural) Quality."
 - a) Grade A, Fy - 33 ksi: 18 gauge and lighter
 - b) Grade D, Fy - 50 ksi: 16 gauge and heavier
 - c) Galvanizing - G-60 Coating Class
- C. American Welding Society:
1. AWS D1.0 "Code for Welding in Building Construction"
 2. ANSI Z49.1 "Safety in Welding and Cutting"

1.5 FABRICATOR'S QUALIFICATIONS

- A. Trusses shall be designed, fabricated, and erected by a firm with a minimum of five years experience designing, fabricating and erecting trussed assemblies similar to scope required.

1.6 SUBMITTALS

- A. **Product data:** Submit certificate, signed by an officer of subcontractor or fabricating firm, indicating that trusses to be supplied for project comply with indicated requirements.
- B. **Shop drawings:** Submit shop drawings showing shapes and dimensions of members to be used including pitch, span, camber configuration and spacing for each type or configuration of truss required. Show bearing and anchorage details. Specify and detail supplemental strapping, bracing clips and other accessories required for proper installation. Shop drawings shall include placement sequences and instructions. Submit design analysis and test reports indicating loading, section properties, allowable stress, stress diagrams and calculations, and similar information needed for analysis and to insure trusses comply with requirements. Designs shall bear the name and seal of a Structural Engineer licensed to practice in the state where the trusses are to be erected.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store and handle products in accordance with the manufacturer's latest published requirements and specifications. Avoid damage from bending, overturning or other causes. Store off-ground in a dry ventilated space or protect with waterproof coverings.
- B. Time the fabrication and erection of trusses to avoid extended on-site storage and delay of the Work.

1.8 PERFORMANCE WARRANTY

- A. Upon completion of work described in this Section, provide in one document the Ten (10) Year Pre-Engineered Roof Truss Limited Warranty, executed jointly by the manufacturer and the Fabricator/Erector. The Limited Performance Warranty coverage shall include uniform load carrying capacity, diaphragm performance, adequacy of connections to support the specified loading and suitability of the assembly to act compatibly with the specified roof deck assembly.

PART 2 – PRODUCTS

2.1 THIS SECTION INTENTIONALLY LEFT BLANK

2.2 ASSEMBLY PERFORMANCE REQUIREMENTS

- A. The pre-engineered light gauge steel truss system shall exhibit the following performance characteristics:

Uniform Total Load Capacity	140 lbs./linear foot or as required per design criteria
Truss Spacing	As shown on drawings
Assembly Weight	10.0lbs./sf. maximum
Wind Uplift Rating	120 mph
Fire Classification	Non-combustible
Factory Mutual Classification	FM Class I
Diaphragm Shear Strength	As shown on drawings
Screwed Connections	Yes
Interior Bearing	No

- B. Basis of Design: Basis of Design is indicated on drawings.

2.3 COMPONENTS

- A. Available Supplier: Subject to compliance with requirements; pre-engineered light gauge prefabricated steel trusses and related components shall be as provided by Advantage Construction Systems, Inc. or Architect approved equal.
- B. Calculations and procedures pertaining to design, analysis, and computation of section properties shall be in accordance with the Specification for the Design of Cold-Formed Steel Structural Members of the American Iron and Steel Institute.
- C. Structural components: shall be Class G-60 galvanized and manufactured from ASTM A-446, Grade A (33 ksi min. yield) for 18 gauge and lighter steel and ASTM A 446, Grade D (50 ksi min. yield) for 16 gauge and heavier steel.

2.4 FASTENERS

- A. Framing components shall be field or shop fabricated and joined to one another by means of welding or screws as recommended by the component provider.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Visually examine and verify that receiving surfaces of the substructure have no apparent defects or errors which would result in substandard workmanship. Additionally, the following items shall be inspected prior to roof truss installation.
1. Bearing Plates:
 - a) Properly positioned within Bond Beam.
 - b) Installed so as to allow complete and adequate contact with truss connection member.

- c) Installed in proper elevations to permit the installation of truss system without the use of shims.

B. Report unsatisfactory conditions to the Architect.

3.2 PREPARATION

- A. **Structural Adequacy:** Contractor shall prepare the structure to insure proper and adequate structural support for the materials specified.

3.3 FABRICATION

- A. Light gauge steel trusses may be fabricated either on the jobsite or at the fabricator's shop.
- B. Trusses shall be fabricated and erected in strict accordance with the current printed instructions of the approved subcontractor or fabricator.
- C. Truss components shall be straight and true prior to fabrication. Flattening or straightening of components, when necessary, shall be accomplished in a manner so as to not damage the component.
- D. Truss components shall be cut neatly to fit snugly against adjacent members.
- E. No splices will be allowed in trusses except as authorized in writing by the Architect or as shown on the approved shop drawings.
- F. Provide clips, angles and other miscellaneous pieces necessary to attach light gauge steel trusses to the substructure or to attach other components within this section to one another.
- G. Trusses shall be erected true and plumb and properly bridged and braced in accordance with the approved shop drawings.
- H. Truss components shall be connected to one another by means of screw attachment or by welding.
- I. Completed trusses shall be free from twists, bends, or open joints with members straight and true to line.
- J. Clean, wire brush, prime and paint with a high zinc content paint equivalent to the original G-60 galvanized coating.

3.4 ERECTION

- A. Brace against racking. Lift trusses so as to not cause local distortion in any member.
- B. Erect by approved methods using equipment of adequate capacity to safely perform the work.
- C. The contractor is responsible for checking the dimensions and assuring the fit of members and trusses before erection begins.
- D. Erect plumb and level and to dimensions, spacings indicated on the drawings.
- E. Components shall be of the size and spacing shown on the approved shop drawings.
- F. Provide web stiffeners and reinforcement at reaction points where required by analysis or to suit details.

- G. Hoist units in place by means of lifting equipment suited to sizes and types of trusses required, applied at designated lift points as recommended by fabricator, exercising care not to damage truss members.
- H. Provide temporary bracing as required to maintain trusses plumb, parallel and in location indicated, until permanent bracing is installed.
- I. Anchor trusses securely at bearing points to comply with methods and details indicated.
- J. Install permanent bracing and related components to enable trusses to maintain design spacing, withstand live and dead loads, and comply with other indicated requirements.
- K. Do not cut or remove truss members.

END OF SECTION 05 45 00

SECTION 05 52 13 - PIPE AND TUBE RAILINGS

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. Aluminum pipe and tube railings.

1.3 PERFORMANCE REQUIREMENTS

- A. **Delegated Design:** Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. **General:** In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:
 - 1. **Aluminum:** The lesser of minimum yield strength divided by 1.65 or minimum ultimate tensile strength divided by 1.95.
- C. **Structural Performance:** 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. (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. **Infill of Guards:**
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- D. **Thermal Movements:** Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
 - 1. **Temperature Change:** 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- E. **Control of Corrosion:** Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 ACTION SUBMITTALS

- A. **Product Data:** For the following:
 - 1. **Grout.**
 - B. **Shop Drawings:** Include plans, elevations, sections, details, and attachments to other work.
 - C. **Samples for Initial Selection:** For products involving selection of color, texture, or design.
 - D. **Samples for Verification:** For each type of exposed finish required.
 - 1. **Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.**
 - 2. **Fittings and brackets.**
 - 3. **Assembled Sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Sample need not be full height.**
 - a. **Show method of finishing and connecting members at intersections.**
 - E. **Delegated-Design Submittal:** For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. **Qualification Data:** For qualified professional engineer.
- B. **Mill Certificates:** Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.
- C. **Welding certificates.**
- D. **Product Test Reports:** Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

1.6 QUALITY ASSURANCE

- A. **Source Limitations:** Obtain each type of railing from single source from single manufacturer.
- B. **Welding Qualifications:** Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. **Welding Qualifications:** Qualify procedures and personnel according to the following:
 - 1. **AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."**

1.7 PROJECT CONDITIONS

- A. **Field Measurements:** Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

1.8 COORDINATION AND SCHEDULING

- 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 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.
- C. 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

2.1 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. **Aluminum Pipe and Tube Railings:**
 - a. ATR Technologies, Inc.
 - b. Blum, Julius & Co., Inc.
 - c. Braun, J. G., Company; a division of the Wagner Companies.
 - d. CraneVeyor Corp.
 - e. Hollaender Manufacturing Company.
 - f. Kee Industrial Products, Inc.
 - g. Moultrie Manufacturing Company.
 - h. Pisor Industries, Inc.
 - i. Sterling Dula Architectural Products, Inc.; Div. of Kane Manufacturing.
 - j. Superior Aluminum Products, Inc.
 - k. Thompson Fabricating, LLC.
 - l. Tri Tech, Inc.
 - m. Tubular Specialties Manufacturing, Inc.
 - n. Tuttle Railing Systems; Div. of Tuttle Aluminum & Bronze, Inc.
 - o. Wagner, R & B, Inc.; a division of the Wagner Companies.

2.2 METALS, GENERAL

- A. **Metal Surfaces, General:** Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

2.3 ALUMINUM

- A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
- B. Extruded Tubing: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
- C. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
- 1. Provide Standard Weight (Schedule 40) pipe, unless otherwise indicated.
 - D. Drawn Seamless Tubing: ASTM B 210 (ASTM B 210M), Alloy 6063-T832.
 - E. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.
 - F. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.
 - G. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.4 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- 1. For aluminum railings, 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. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.5 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 inch (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. Provide shop tig welding to the greatest extent possible. All field welds shall be tig welds.
- 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.
- 5. Polish as requested for smooth even finish appearance.
- I. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

2.6 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.

2.7 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 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.

3.2 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 inch in 3 feet (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 1/4 inch in 12 feet (5 mm in 3 m).
- C. Corrosion Protection: 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.
- D. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.3 RAILING CONNECTIONS

- A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.
- B. 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 inches (50 mm) beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches (150 mm) of post.

3.4 ANCHORING POSTS

- A. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material or attached to post with set screws.

3.5 ADJUSTING AND CLEANING

- A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.6 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.

END OF 05 52 13

SECTION 06 16 00 – SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 1. Gypsum based sheathing.
 2. Sheathing joint-and-penetration treatment.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Stack plywood and other panels flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WALL SHEATHING

- A. Glass-Mat Gypsum Wall Sheathing: ASTM C 1177/1177M.
 1. Product: Subject to compliance with requirements, "Dens-Glass Gold" by G-P Gypsum Corporation.
 2. Type and Thickness: Regular, 1/2 inch
 3. Size: 48 by 96 inches for vertical installation.

2.2 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
- B. Nails, Brads, and Staples: ASTM F 1667.
- C. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing board to be attached, with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.
 1. For steel framing less than 0.0329 inch thick, attach sheathing to comply with ASTM C 1002.
 2. For steel framing from 0.033 to 0.112 inch thick, attach sheathing to comply with ASTM C 954.

PART 3 - EXECUTION

3.1 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.
- 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. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."
- D. Use steel screws coated or uncoated to suit substrate and framing, unless otherwise indicated. Select fasteners of size that will penetrate members to degree recommended by framing manufacturer, but will not penetrate fully through to exposed to view surfaces on the opposite side. Make tight connections. Install fasteners without splitting wood.
- E. Coordinate roof and 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.
- F. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- G. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 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-inch gap where non-load-bearing construction abuts structural elements.
 - 3. Install boards with a 1/4-inch gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.
- B. Apply fasteners so heads bear tightly against face of sheathing boards but do not cut into facing.
- C. Vertical Installation: Install board vertical edges centered over studs. Abut ends and edges of each board with those of adjacent boards. Attach boards at perimeter and within field of board to each stud.
 - 1. Space fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of boards.
 - 2. For sheathing under stucco cladding, boards may be initially tacked in place with screws if overlying self-furring metal lath is screw-attached through sheathing to studs immediately after sheathing is installed.

3.3 SHEATHING JOINT-AND-PENETRATION TREATMENT

- A. Seal sheathing joints according to sheathing manufacturer's written instructions.
- 1. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing board 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.

3.4 FLEXIBLE FLASHING INSTALLATION

- A. Apply flexible flashing where indicated to comply with manufacturers written instructions.
- 1. Prime substrates as recommended by flashing manufacturer.
- 2. Lap seams and junctures with other materials at least 4 inches, except that at flashing flanges of other construction, laps need not exceed flange width.
- 3. After flashing has been applied, roll surfaces with a hard rubber or metal roller to ensure that flashing is completely adhered to substrates.

END OF SECTION 06 16 00

SECTION 07 41 10 - METAL ROOF PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Factory-formed and field-assembled, concealed-fastener, standing-seam metal roof panels.

1.2 PERFORMANCE REQUIREMENTS

A. **Structural Performance:** Capable of withstanding the effects of gravity loads and the following loads and stresses, based on testing according to ASTM E 1592:

1. **Wind Loads:** Minimum design wind pressures as defined on structural drawing AS-001.
2. **Snow Loads:** 10 lbf/sq. ft.
3. **Deflection Limits:** Withstand test pressure with deflection no greater than 1/180 of the span and no evidence of material failure, structural distress or permanent deformation exceeding .2% of the clear span.

Test pressures: 150 percent of inward and outward wind load design pressures.

4. Meets or exceeds Section 6, ASCE 7 Performance Criteria.

1.3 SUBMITTALS

A. **Product Data:** For each type of metal roof panel and accessory indicated.

B. **Shop Drawings:** Show layouts of metal roof panels, including plans, elevations, sections, details, and attachments to other work.

1. Include details of edge conditions, joints, panel profiles, corners, anchorages, trim, flashings, closures, and accessories.
2. Include structural analysis data signed and sealed by the qualified professional engineer, registered in the state of North Carolina, responsible for their preparation.

C. **Coordination Drawings:** Drawn to scale and coordinating metal roof panel installation with penetrations and roof-mounted items.

D. **Samples:** For each exposed finish and profile.

E. **Material certificates.**

F. **Field quality-control inspection reports.**

G. **Product test reports.**

H. **Maintenance data.**

1.4 QUALITY ASSURANCE

- A. **Installer Qualifications:** An employer of workers trained and approved by manufacturer.
1. **Installer's responsibilities** include fabricating and installing metal roof panel assemblies and providing professional engineering services needed to assume engineering responsibility.

1.5 WARRANTY

- A. **Special Manufacturer's Warranty:** Manufacturer agrees to repair or replace components of metal roof panel assemblies that fail in materials or workmanship within specified warranty period. This warranty shall cover labor and materials up to the amount of the original installation. Include flashing, ridges and valleys, gutters and accessories, be non-prorated, not require annual inspections and not require any leak free period of time.
1. **Failures include, but are not limited to, the following:**
 - Structural failures, including rupturing, cracking, or puncturing.
 - Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - Weathertightness of complete roof system.
 2. **Warranty Period:** 20 years from date of Final Acceptance.
- B. **Special Warranty on Panel Finishes:** Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal roof panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
1. **Fluoropolymer Finish Warranty Period:** 20 years from date of Final Acceptance.
 - C. **The Contractor (Roofing System Installer)** shall warrant the materials and workmanship of the roofing system against leakage and against defects due to faulty materials, workmanship and contract negligence for a period of two (2) years following acceptance of the project by the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:
1. **Manufacturers:** Subject to compliance with requirements. Provide products by one of the manufacturers listed in other part 2 articles.

2.2 PANEL MATERIALS

- A. **Metallic-Coated Steel Sheet Prepainted with Coil Coating:** Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
1. **Aluminum-Zinc Alloy-Coated Steel Sheet:** ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; structural quality.
 2. **Surface:** Smooth, flat finish.
 3. **Exposed Finishes:**
 - High-Performance Organic Finish: Two-coat, thermocured system with fluoropolymer coats containing not less than 70 percent polyvinylidene fluoride resin by weight;

complying with physical properties and coating performance requirements of AAMA 2604, except as modified below:

- 1) Humidity Resistance: 1000 hours.
- 2) Water Resistance: 1000 hours.

B. Panel Sealants:

1. Sealant Tape: Pressure-sensitive, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch wide and 1/8 inch thick.
2. Joint Sealant: ASTM C 920; as recommended in writing by metal roof panel manufacturer.
3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.3 FIELD-INSTALLED THERMAL INSULATION

- A. Unfaced, Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1 Grade 2, min., compressive strength of 20 psi with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, based on tests performed.
- B. Board size: 4-foot by 8-foot (1.2-m by 2.4-m) maximum board size for loose-laid and mechanically attached insulation boards and 4-foot by 4-foot (1.2-m by 1.2-m) maximum board size for insulation boards adhered to a substrate.
- C. Board thickness: 2 inches (51 mm) maximum; when thicker total thicknesses are required, provide insulation boards in multiple layers to achieve total specified thickness. When multiple insulation layers are used, the insulation board's joints in the topmost layer (cover board) should be staggered vertically and offset from the joints in the underlying layers.

2.4 ROOFING UNDERLAYMENT

- A. 40 mil roofing underlayment will be on all roof eaves, valleys, gables, ridges and other penetration areas to attain the 20 year weathertightness warranty. Underlayment shall be non-granular "smooth" made be from the following manufacturers:
 1. GAF Corporation: "Metal Mate"
 2. Carlisle: CCW WIP 300 HT
 3. Interwrap: Titanium PSU
 4. Polyguard: Deck Guard HT or Polyglas HT
 5. MFM Corp: "Wind & Water Shield"
 6. W.R. G race: "Ice & Water Shield"
 7. TAMKO: "TW Tile & Metal Underlayment"

In the "field" of roof, 30# asphalt felt paper shall be used for the underlayment.

- B. Underlayment shall be laid in horizontal layers with joints lapped toward the eaves a minimum of 6" and well secured along laps and at ends as necessary to properly hold the underlayment in place. All underlayment shall be preserved unbroken and whole.
- C. Underlayment shall lap all hips and ridges at least 12" to form double thickness and shall be lapped 6" over the metal of any valleys or built-in gutters and shall be installed as required by the Standing Seam Panel Manufacturer to attain the desired 20 year weathertightness warranty.

2.5 MISCELLANEOUS MATERIALS

- A. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal roof panels by means of plastic caps or factory-applied coating.
 - 1. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head. Fasteners shall be 410 stainless or zinc alloy steel.
 - 2. Blind Fasteners: High-strength aluminum or stainless-steel rivets.

2.6 METAL ROOF PANELS

- A. Standing-Seam Metal Roof Panels: Factory-formed, designed to be field assembled by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.
 - 1. Steel Panel Systems: Comply with ASTM E 1514.
 - 2. Manufacturers:
 - Peterson Aluminum
 - AEP Span
 - Morin Corporation
 - 3. Basis of Design: Peterson Aluminum - snapclad
 - 4. Type: Vertical rib, seamed joint as indicated on Drawings.
 - 5. Material: Metallic-coated steel sheet, 24 ga. thickness minimum. Increase gauge if required for specified loading conditions.
 - Exterior Finish: Fluoropolymer.
 - Custom color as selected by Architect.
 - 6. Clips and Bearing Plate: Floating to accommodate thermal movement.
 - Material: Metallic-coated-steel sheet.
 - 7. Joint Type: As standard with manufacturer.
 - 8. Panel Coverage: 16"
 - 9. Panel Height: full length of roof from eave to ridge.
 - 10. Uplift Rating: Section 6, ASCE 7.

2.7 ACCESSORIES

- A. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including trim, copings, fascia, corner units, ridge closures, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels, unless otherwise indicated.
 - 1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal roof panels.
 - 2. Clips: Minimum 0.0625-inch- thick, stainless-steel panel clips designed to withstand negative-load requirements. Panel clips may be galvanized steel at contractor's option.
 - 3. Cleats: Mechanically seamed cleats formed from minimum 0.0250-inch- thick, stainless-steel or nylon-coated aluminum sheet.
 - 4. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

- B. **Roof Curbs:** Fabricated from 0.0478-inch- thick, metallic-coated steel sheet; with welded top box and bottom skirt, and integral full-length cricket. Fabricate curb subframing of minimum 0.0598-inch- thick, angle-, C-, or Z-shaped steel sheet. Fabricate curb and subframing to withstand indicated loads, of size and height indicated. Finish roof curbs to match metal roof panels.

2.8 FABRICATION

- A. **General:** Fabricate and finish metal roof panels and accessories at the factory to greatest extent possible, 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. Where indicated, fabricate metal roof panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will minimize noise from movements within panel assembly.
- D. **Sheet Metal Accessories:** Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.
- E. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.1 METAL ROOF PANEL INSTALLATION, GENERAL

- A. **General:** Provide metal roof panels of full length from eave to ridge, unless otherwise indicated or restricted by shipping limitations. Anchor metal roof panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 1. Field cutting of metal roof panels by torch is not permitted.
 2. Rigidly fasten eave end of metal roof panels and allow ridge end free movement due to thermal expansion and contraction. Pre-drill panels.
 3. Provide metal closures at exposed edges of roof and fascia panels.
 4. Flash and seal metal roof panels with weather closures at eaves, rakes, and at perimeter of all openings. Fasten with self-tapping screws.
 5. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
 6. Lap metal flashing over metal roof panels to allow moisture to run over and off the material.
- B. **Fasteners:**
 1. **Steel Roof Panels and Accessories:** Use stainless-steel fasteners for surfaces exposed to the exterior and galvanized steel fasteners for surfaces exposed to the interior.

- C. **Metal Protection:** Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.
- D. **Joint Sealers:** Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal roof panel assemblies.
 - 1. Seal metal roof panel end laps with double beads of tape or sealant, full width of panel. Seal side joints where recommended by metal roof panel manufacturer.
 - 2. Prepare joints and apply sealants to comply with requirements in Division 7 Section "Joint Sealants."

3.2 THERMAL INSULATION INSTALLATION FOR FIELD-ASSEMBLED METAL ROOF PANELS

- A. **Board Insulation:** Extend insulation in thickness indicated to cover entire roof. Comply with installation requirements as recommended by roofing supplier and installer to meet wind loading requirements.

3.3 FIELD-ASSEMBLED METAL ROOF PANEL INSTALLATION

- A. **Standing-Seam Metal Roof Panels:** Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended by manufacturer.
 - 1. Install clips to supports with self-tapping fasteners.

3.4 ACCESSORY INSTALLATION

- A. **General:** Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.
 - 1. Install components required for a complete metal roof panel assembly including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
 - 2. 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 as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.
 - 3. Provide elbows at base of downspouts to direct water away from building.
 - 4. Tie downspouts to underground drainage system indicated.

3.5 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal roof panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal roof panel installation, clean finished surfaces as recommended by metal roof panel manufacturer. Maintain in a clean condition during construction.

END OF SECTION 07 41 10

SECTION 07 41 20 - METAL WALL PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concealed-fastener, lap-seam metal wall panels.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal wall panel assemblies capable of withstanding the effects the following loads and stresses within limits and under conditions indicated, based on testing according to ASTM E 1592:

1. Wind Loads: Determine loads based on the following minimum design wind pressures:
Minimum wind pressures as defined on structural drawing AS-001.
2. Deflection Limits: Metal wall panel assemblies shall withstand wind loads with horizontal deflections no greater than 1/180 of the span.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication and installation layouts of metal wall panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details. Distinguish between factory-, shop- and field-assembled work.
- C. Samples: For each type of exposed finish required.
- D. Submit structural analysis data in accordance with the AISI specification for the design of cold formed steel structural members for the metal wall panel system. Drawings are to be signed and sealed by a qualified professional engineer responsible for their preparation.
- E. Coordination Drawings: Exterior elevations drawn to scale and coordinating penetrations and wall-mounted items.
- F. Maintenance data.
- G. Warranties: Samples of special warranties.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Preinstallation Conference: Conduct conference at Project site.

ADA

1.5 WARRANTY

- A. **Special Warranty:** Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal wall panel assemblies that fail in materials or workmanship within specified warranty period.
 - 1. **Warranty Period:** One year 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 wall 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.

PART 2 - PRODUCTS

2.1 PANEL MATERIALS

- A. **Metallic-Coated Steel Sheet:** Restricted flatness steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - 1. **Zinc-Coated (Galvanized) Steel Sheet:** ASTM A 653/A 653M, G90 (Z275) coating designation; structural quality.
 - 2. **Aluminum-Zinc Alloy-Coated Steel Sheet:** ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40 (Class AZM150 coating designation, Grade 275); structural quality.
 - 3. **Surface:** Smooth, flat finish.
 - 4. **Exposed Coil-Coated Finish:**
 - 2-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat.
 - 5. **Concealed Finish:** Manufacturer's standard white or light-colored acrylic or polyester backer finish.
- B. **Panel Sealants:**
 - 1. **Sealant Tape:** Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing; 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.
 - 2. **Joint Sealant:** ASTM C 920 as recommended in writing by metal wall panel manufacturer.
 - 3. **Butyl-Rubber-Based, Solvent-Release Sealant:** ASTM C 1311.
- C. **All exterior metal flashing adjacent to metal wall panel shall be fabricated in the same material, finish, and color as the exterior profile unless noted otherwise.**

2.2 FIELD-INSTALLED THERMAL INSULATION

- A. **Refer to Division 7 Section "Building Insulation."**

2.3 MISCELLANEOUS MATERIALS

- A. **Panel Fasteners:** Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal wall panels by means of plastic caps or factory-applied coating. Provide EPDM, PVC, or neoprene sealing washers.

2.4 CONCEALED-FASTENER, LAP-SEAM METAL WALL PANELS

- A. Provide factory-formed metal wall panels designed to be field assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 2. **Basis-of-Design Product:** Subject to compliance with requirements, provide Centria Concept Series CS-660, or comparable product by one of the following:
 - AEP-Span.
 - Alcoa Architectural Products (USA).
 - Architectural Metal Systems.
 - ATAS International, Inc.
 - Metecno-Morin.
 - Petersen Aluminum Corporation.
 3. **Profile:** Flush.
 4. **Material:** Zinc-coated (galvanized) steel sheet, 20 gage / .040 inch nominal thickness.
 - Exterior Finish: 2-coat fluoropolymer.
 - Color: As selected by Architect from manufacturer's full range.
 5. **Panel Depth:** 7/8".
 6. **Panel Height:** 16" and 12".

2.5 ACCESSORIES

- A. **Wall Panel Accessories:** Provide components required for a complete metal wall panel assembly including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels, unless otherwise indicated.
1. **Closures:** Provide closures at eaves and rakes, fabricated of same metal as metal wall 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 crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- (25-mm-) thick, flexible closure strips; cut or premolded to match metal wall panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- B. **Flashing and Trim:** Formed from 0.018-inch (0.46-mm) minimum thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal wall panels.

2.6 FABRICATION

- A. **General:** Fabricate and finish metal wall panels and accessories at the factory to greatest extent possible, 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. Fabricate metal wall panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.
- C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- D. Fabricate metal wall panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, and that will minimize noise from movements within panel assembly.
- E. Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Miscellaneous Framing: Install subgirts, base angles, sills, furring, and other miscellaneous wall panel support members and anchorages according to ASTM C 754 and metal wall panel manufacturer's written recommendations.

3.2 METAL WALL PANEL INSTALLATION

- A. Lap-Seam Metal Wall Panels: Fasten metal wall panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 1. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.
 2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal wall panels.
 3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 5. Provide sealant tape at lapped joints of metal wall panels and between panels and protruding equipment, vents, and accessories.
 6. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps; on side laps of nesting-type panels; on side laps of corrugated nesting-type, ribbed, or fluted panels; and elsewhere as needed to make panels weathertight.
 7. At panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.
- B. Metal Soffit Panels: Provide metal soffit panels full width of soffits. Install panels perpendicular to support framing.
 1. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of all openings.

3.3 ACCESSORY INSTALLATION

- A. General: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
- 1. 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.
- B. 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 as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

3.4 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal wall panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal wall panel installation, clean finished surfaces as recommended by metal wall panel manufacturer. Maintain in a clean condition during construction.
- B. After metal wall panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

END OF SECTION 07 41 20

SECTION 07 62 00 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Formed roof drainage system.
2. Formed wall flashing and trim.

1.2 SUBMITTALS

- A. **Product Data:** For each product indicated.
- B. **Shop Drawings:** Show layouts, profiles, shapes, seams, dimensions, and details for fastening, joining, supporting, and anchoring sheet metal flashing and trim.
- C. **Samples:** For each type of sheet metal flashing and trim.
- D. Provide drawings and details designating location and construction of gutter expansion joints.

1.3 QUALITY ASSURANCE

- A. **Sheet Metal Flashing and Trim Standard:** Comply with SMACNA's "Architectural Sheet Metal Manual." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
- B. **Mockups:** Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 1. Build mockup of typical roof eave, including built-in gutter, fascia, fascia trim, apron flashing, approximately 48 inches long, including supporting construction cleats, seams, attachments, underlayment, and accessories.
 2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. **Preinstallation Conference:** Conduct conference at Project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. **Available Manufacturers:** Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 SHEET METALS

- A. **Prepainted, Metallic-Coated Steel Sheet:** Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
- 1. **Aluminum-Zinc Alloy-Coated Steel Sheet:** ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; structural quality. Minimum thickness 22 gage.
- 2. **Exposed Finishes:** Apply the following coil coating:
 - High-Performance Organic Finish: Two-coat thermocured system containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with physical properties and coating performance requirements of AAMA 2604, except as modified for below:
 - 1) Humidity and Salt Spray Resistance: 1000 hours.
 - 2) Custom color as selected by Architect.

2.3 MISCELLANEOUS MATERIALS

- A. **General:** Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation.
- B. **Flashing Underlayment:** 40 mil roofing underlayment shall be non-granular "smooth" made from the following manufacturers:
 - 1. GAF Corporation: "Metal Mate"
 - 2. Carlisle: CCW WIP 300 HT
 - 3. Interwrap: Titanium PSU
 - 4. Polyguard: Deck Guard HT or Polyglas HT
 - 5. MFM Corp: "Wind & Water Shield"
 - 6. W.R. Grace: "Ice & Water Shield"
 - 7. TAMKO: "TW Tile & Metal Underlayment"
- C. **Fasteners:** Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads.
 - 1. **Exposed Fasteners:** Heads matching color of sheet metal by means of plastic caps or factory-applied coating.
 - 2. **Fasteners for Flashing and Trim:** Blind fasteners or self-drilling screws, gasketed, with hex washer head.
 - 3. **Blind Fasteners:** High-strength aluminum or stainless-steel rivets.
- D. **Sealing Tape:** Pressure-sensitive, 100 percent solids, polyisobutylene compound sealing tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape.
- E. **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.
- F. **Epoxy Seam Sealer:** Two-part, noncorrosive, aluminum seam-cementing compound.

2.4 FABRICATION, GENERAL

- A. **General:** Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and

other characteristics of item indicated. Shop fabricate items where practicable. Obtain field measurements for accurate fit before shop fabrication.

- B. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
- 1. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
- C. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.
- D. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with elastomeric sealant concealed within joints.
- E. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.
- F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal, and in thickness not less than that of metal being secured.

2.5 ROOF DRAINAGE SHEET METAL FABRICATIONS

- A. Hanging Gutters: Fabricate to cross section indicated, complete with end pieces, outlet tubes, and other accessories as required. Fabricate in minimum 96-inch- long sections. Furnish flat-stock gutter spacers and gutter brackets fabricated from same metal as gutters, of size recommended by SMACNA but not less than twice the gutter thickness. Fabricate expansion joints, expansion-joint covers, and gutter accessories from same metal as gutters.
 - 1. Accessories: Wire ball downspout strainer.
 - 2. Fabricate from the following material:
 - Aluminum-Zinc Alloy-Coated Steel: 0.0336 inch thick.
- B. Downspouts: Fabricate rectangular downspouts complete with mitered elbows. Furnish with metal hangers, from same material as downspouts, and anchors.
 - 1. Fabricate downspouts from the following material:
 - Aluminum-Zinc Alloy-Coated Steel: 0.0217 inch thick.
- C. Apron, Strap, Cricket and Backer Flashing: Fabricate from following material;
 - 1. Preprinted, metallic-coated steel: 0.0276 inch thick.
- D. Drip Edges: Fabricate from the following materials:
 - 1. Preprinted, metallic-coated steel: 0.0276 inch thick.

PART 3 - EXECUTION

3.1 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, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
- 1. Torch cutting of sheet metal flashing and trim is not permitted.
- B. **Metal Protection:** Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by fabricator or manufacturers of dissimilar metals.
- C. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
- D. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and elastomeric sealant.
- E. 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.
- F. **Expansion Provisions:** Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with elastomeric sealant concealed within joints.
- G. **Fasteners:** Use fasteners of sizes that will penetrate substrate not less than 1-1/4 inches for nails and not less than 3/4 inch for wood screws.
- 1. **Galvanized or Prepainted, Metallic-Coated Steel:** Use stainless-steel fasteners.
- H. Seal joints with elastomeric sealant as required for watertight construction.

3.2 ROOF DRAINAGE SYSTEM INSTALLATION

- A. **General:** Install sheet metal roof drainage items to produce complete roof drainage system according to SMACNA recommendations and as indicated. Coordinate installation of roof perimeter flashing with installation of roof drainage system.
- B. **Hanging Gutters:** Join sections with riveted and soldered joints or with lapped joints sealed with elastomeric sealant. Provide for thermal expansion. Attach gutters at eave or fascia to firmly anchored straps spaced not more than 36 inches apart. Provide end closures and seal watertight with sealant. Slope to downspouts.
- 1. Install gutter with expansion joints at locations indicated but not exceeding 50 feet apart. Install expansion joint caps.
- 2. Install continuous gutter screens on gutters with noncorrosive fasteners, hinged to swing open for cleaning gutters.

- C. Downspouts: Join sections with 1-1/2-inch telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom and at approximately 60 inches o.c. in between.

3.3 ROOF FLASHING INSTALLATION

- A. General: Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, set units true to line, and level as indicated. Install work with laps, joints, and seams that will be permanently watertight.
- B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-120.
 - 1. Interlock bottom edge of roof edge flashing with continuous cleats anchored to substrate at 16-inch centers.
- C. Copings: Anchor to resist uplift and outward forces according to recommendations in FMG Loss Prevention Data Sheet 1-120.
 - 1. Interlock exterior bottom edge of coping with continuous cleats anchored to substrate at 16-inch centers.
 - 2. Anchor interior leg of coping with screw fasteners and washers at 18-inch centers.
- D. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Secure in a waterproof manner. Extend counterflashing 4 inches over base flashing. Lap counterflashing joints a minimum of 4 inches and bed with elastomeric sealant.

END OF SECTON 07 62 00

SECTION 08 41 13 - ALUMINUM ENTRANCES AND STOREFRONT AND GLAZING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
1. Exterior aluminum-framed storefronts.
 - a. Glazing is retained mechanically with gaskets on four sides.
 2. Exterior aluminum horizontal slider window.
 - a. Window unit to be mounted within storefront system.
 3. Exterior manual-swing aluminum door and frame units.
 4. Glazing

1.2 PERFORMANCE REQUIREMENTS

- A. **General:** Provide aluminum-framed systems, including anchorage, capable of withstanding, without failure, the effects of the following:
1. Structural loads.
 2. Thermal movements.
 3. Movements of supporting structure indicated on Drawings including, but not limited to, story drift and deflection from uniformly distributed and concentrated live loads.
 4. Dimensional tolerances of building frame and other adjacent construction.
- B. **Structural-Sealant Joints:** Designed to produce tensile or shear stress in structural-sealant joints of less than 20 psi.
- C. **Structural Loads:**
1. **Wind Loads:** Minimum design wind pressures as defined on structural drawing AS-001.
- D. **Deflection of Framing Members Normal to Wall Plane:** Limited to 1/175 of clear span for spans up to 13 feet 6 inches and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.
- E. **Structural-Test Performance:** Systems tested according to ASTM E 330 as follows:
1. When tested at positive and negative wind-load design pressures, systems do not evidence deflection exceeding specified limits.
 2. When tested at 150 percent of positive and negative wind-load design pressures, systems, including anchorage, do not evidence material failures, structural distress, and permanent deformation of main framing members exceeding 0.2 percent of span.
 3. **Test Durations:** As required by design wind velocity but not less than 10 seconds.
- F. **Temperature Change (Range):** Systems accommodate 120 deg F, ambient; 180 deg F, material surfaces.

- G. **Air Infiltration:** Maximum air leakage through fixed glazing and framing areas of systems of 0.06 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft..
- H. **Water Penetration Under Static Pressure:** Systems 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 8 lbf/sq. ft as defined in AAMA 501.
- I. **Condensation Resistance:** Fixed glazing and framing areas of systems have condensation-resistance factor (CRF) of not less than 53 when tested according to AAMA 1503.
- J. **Average Thermal Conductance:** Fixed glazing and framing areas of systems have average U-factor of not more than 0.69 Btu/sq. ft. x h x deg F when tested according to AAMA 1503.

1.3 SUBMITTALS

- A. **Product Data:** For each type of product indicated.
- B. **Shop Drawings:** Include plans, elevations, sections, details, and attachments to other work.
 - 1. Include structural analysis data signed and sealed by the qualified professional engineer, registered in the State of North Carolina, responsible for their preparation.
- C. **Samples:** For each exposed finish.
- D. **Product test reports.**

1.4 QUALITY ASSURANCE

- A. **Installer Qualifications:** Acceptable to manufacturer and capable of preparation of data for aluminum-framed systems including Shop Drawings based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. **Mockups:** Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 - 1. Build mockups of each specified system.
 - 2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 WARRANTY

- A. **Special Assembly Warranty:** Manufacturer's standard form in which manufacturer agrees to repair or replace components of aluminum-framed systems that do not comply with requirements or that deteriorate as defined in this Section 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. Noise or vibration caused by thermal movements.

- c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - d. Adhesive or cohesive sealant failures.
 - e. Water leakage through fixed glazing and framing areas.
 - f. Failure of operating components to function properly.
2. Warranty Period: Five years from date of Substantial Completion.
 - B. Special Finish Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components on which finishes fail within specified warranty period. Warranty does not include normal weathering.
 1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. EFCO Corporation
 2. Kawneer
 3. United States Aluminum
 4. Vistawall Architectural Products
- B. Basis-of-Design Product: The design for aluminum-framed systems is based on the Kawneer product line. Subject to compliance with requirements, provide the named product or a comparable product by one of the following:
 1. Aluminum Storefront
 - a. Kawneer Trifab 451
 2. Aluminum Sliding Windows
 - a. Kawneer 8400TL Isolock Window
 3. Doors
 - a. Kawneer 2000T Terrace Door

2.2 MATERIALS

- A. Aluminum: Alloy and temper recommended 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/B 308M.
- B. Steel Reinforcement: With manufacturer's standard corrosion-resistant primer.
 1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
 2. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
 3. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

2.3 FRAMING SYSTEMS

- A. Framing Members: Manufacturer's standard extruded-aluminum framing members of thickness required and reinforced as required to support imposed loads.
 - 1. Method of construction: Screw block, non thermal
- B. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.
- C. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
 - 1. Where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration, use self-locking devices.
 - 2. Reinforce members as required to receive fastener threads.
 - 3. Use exposed fasteners with countersunk Phillips screw heads, finished to match framing system.
- D. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.
- E. Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials. Form exposed flashing from sheet aluminum finished to match framing and of sufficient thickness to maintain a flat appearance without visible deflection.
- F. Framing System Gaskets and Sealants: Manufacturer's standard recommended by manufacturer for joint type.

2.4 GLAZING SYSTEMS

A. SUBMITTALS

- 1. Product Data: For each glass product and glazing material indicated.
- 2. Samples: 12-inch- square, for each type of glass product indicated.
- 3. Glazing Schedule: Use same designations indicated on Drawings.
- 4. Sealant compatibility and adhesion test reports.

B. WARRANTY

- 1. Special Warranty: Manufacturer's standard form, made out to Owner and signed by manufacturer, in which manufacturer agrees to furnish replacements for units that deteriorate from normal use by developing defects attributable to the manufacturing process, f.o.b. the nearest shipping point to Project site, within warranty period.
 - a. Coated Glass:
 - 1) Defects: Peeling, cracking, and other indications of deg radation of metallic coating.
 - 2) Warranty Period: 10 years from date of Substantial Completion.
 - b. Insulating Glass:
 - 1) Deterioration: Failure of hermetic seal resulting in obstruction of vision by dust, moisture, or film on interior surfaces of glass.
 - 2) Warranty Period: 10 years from date of Substantial Completion.

C. INSULATING-GLASS SCHEDULE

1. Manufacturers:
 - a. Guardian Industries
 - b. Pilkington
 - c. PPG Industries, Inc.
 - d. Oldcastle 500 Low E:
2. Insulated Glass G-1:
 - a. PPG Solarban 60
 - b. Overall Unit Thickness and Thickness of Each Lite: 25 and 6 mm.
 - c. Interspace Content: Air.
 - d. Indoor Lite: Tempered clear.
 - e. Outdoor Lite: Tempered glass Solarban 60 #2 side
 - f. Visible Light Transmittance: 69
 - g. Winter Nighttime U-Value: .29
 - h. Summer Daytime U-Value: .29
 - i. Solar Heat Gain Coefficient: .37
 - j. Winter Nighttime U-Value: .29
 - k. Shading Coefficient: .41
 - l. Light to Solar Gain Ratio: 1.67

2.5 DOORS

- A. Doors: Manufacturer's standard glazed doors, for manual swing operation.
1. Door Construction: 1-inch overall thickness, with minimum 0.188-inch- thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deep penetration and fillet welded or that incorporate concealed tie rods.
 2. Glazing Stops and Gaskets: Manufacturer standard.

2.6 DOOR HARDWARE

- A. Standard Hardware Provided by Manufacturer:
1. Pivot: 1.5 Pair
 2. Lever set: Manufacturer Standard
 3. Cylinder: Manufacturer Standard
 4. Closer: LCN 4041 or equal by Norton or Sargent
 5. Wall Stop: Manufacturer Standard
 6. Threshold: Manufacturer Standard
 7. Weatherstrip: Manufacturer Standard

2.7 HORIZONTAL SLIDING WINDOWS

- A. Storefront mounted sliding window. Coordinate size and installation of sliding window within aluminum storefront framing. Provide storefront mounted accessory trim to receive and anchor sliding window within storefront system. Color and finish to match storefront.

2.7 ACCESSORY MATERIALS

- B. **Insulating Materials:** As specified in Division 7 Section "Building Insulation."
- C. **Joint Sealants:** For installation at perimeter of aluminum-framed systems, as specified in Division 7 Section "Joint Sealants."
- D. **Bituminous Paint:** Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

2.8 FABRICATION

- A. **Form 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. **Framing Members, General:** 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. **Means to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.**
 - 4. **Physical and thermal isolation of glazing from framing members.**
 - 5. **Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.**
 - 6. **Provisions for field replacement of glazing from exterior.**
 - 7. **Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.**
- D. **Door Frames:** Reinforce as required to support loads imposed by door operation and for installing hardware.
 - 1. **At exterior doors, provide compression weather stripping at fixed stops.**
 - 2. **At interior doors, provide silencers at stops to prevent metal-to-metal contact. Install three silencers on strike jamb of single-door frames and two silencers on head of frames for pairs of doors.**
- E. **Doors:** Reinforce doors as required for installing hardware.
 - 1. **At pairs of exterior doors, provide sliding weather stripping retained in adjustable strip mortised into door edge.**
 - 2. **At exterior doors, provide weather sweeps applied to door bottoms.**
- F. **After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.**
- G. **Hardware supplier:** Installation of door hardware is by aluminum storefront supplier.

2.9 ALUMINUM FINISHES

- A. **High-Performance Organic Finish:** Two-coat thermocured system with fluoropolymer topcoats containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2604.
 - 1. As selected from manufacturer's full range.

PART 3 - EXECUTION

PART 4 - INSTALLATION

- A. **General:**
 - 1. Fit joints to produce hairline joints free of burrs and distortion.
 - 2. Rigidly secure nonmovement joints.
 - 3. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration.
 - 4. Seal joints watertight, unless otherwise indicated.
- B. **Metal Protection:**
 - 1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.
 - 2. Where aluminum will 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 the system to exterior.
- D. Set continuous sill members and flashing in full sealant bed as specified in "Joint Sealants" and to produce weathertight installation.
- E. Install components plumb and true in alignment with established lines and grades, without warp or rack.
- F. **Install glazing as specified.**
 - 1. **Structural-Sealant Glazing:**
 - a. Prepare surfaces that will contact structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.
 - b. Install weatherseal sealant according to Division 7 Section "Joint Sealants" and according to sealant manufacturer's written instructions to produce weatherproof joints. Install joint filler behind sealant as recommended by sealant manufacturer.
- G. **Entrances:** Install to produce smooth operation and tight fit at contact points.
 - 1. **Exterior Entrances:** Install to produce tight fit at weather stripping and weathertight closure.
 - 2. **Field-Installed Hardware:** Install surface-mounted hardware according to hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.
- H. Install insulation materials as specified in "Building Insulation."

- I. Install perimeter joint sealants as specified in "Joint Sealants" and to produce weathertight installation.
- J. Erection Tolerances: Install aluminum-framed systems to comply with the following maximum tolerances:
 1. Location and Plane: Limit variation from true location and plane to 1/8 inch in 12 feet; 1/4 inch over total length.
 2. Alignment:
 - a. Where surfaces abut in line, limit offset from true alignment to 1/16 inch.
 - b. Where surfaces meet at corners, limit offset from true alignment to 1/32 inch.
 3. Diagonal Measurements: Limit difference between diagonal measurement to 1/8 inch.

END OF SECTON 08 41 13

SECTION 09 29 00 - GYPSUM BOARD ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Interior gypsum wallboard.
2. Tile backing panels.
3. Non-load-bearing steel framing.

1.2 SUBMITTALS

- A. Product Data:** For each product indicated.
- B. Samples:** For each textured finish indicated and on same backing indicated for Work.

1.3 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.
- B. Sound Transmission Characteristics:** For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:**
1. **Products:** Subject to compliance with requirements, provide one of the products specified.

2.2 STEEL FRAMING

- A. Steel Framing, General:** Comply with ASTM C 754 for conditions indicated.
1. **Steel Sheet Components:** Metal complying with ASTM C 645 requirements.
Protective Coating:
 - 1) **Interior Applications:** ASTM A 653/A 653M, G40, hot-dip galvanized zinc coating.

B. Suspended Ceiling and Soffit Framing:

1. **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.

2. **Hanger Attachments to Concrete:**

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.

- 1) **Type:** Postinstalled, expansion anchor.

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 to 10 times that imposed by construction as determined by testing according to ASTM E 1190 by a qualified independent testing agency.

3. **Wire Hangers:** ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.162-inch diameter.
4. **Carrying Channels:** Cold-rolled, commercial-steel sheet with a base metal thickness of 0.0538 inch, a minimum 1/2-inch- wide flange, and in depth indicated.
5. **Furring Channels (Furring Members):**

Cold Rolled Channels: 0.0538-inch bare steel thickness, with minimum 1/2-inch- wide flange, 3/4 inch deep.

Steel Studs: ASTM C 645, in depth indicated.

- 1) **Minimum Base Metal Thickness:** 0.0312 inch.

Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch deep.

- 2) **Minimum Base Metal Thickness:** 0.0312 inch.

C. Grid Suspension System for Interior Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. **Products:**

Armstrong World Industries, Inc.; Furring Systems/Drywall.

Chicago Metallic Corporation; Drywall Furring 640 System.

USG Interiors, Inc.; Drywall Suspension System.

D. Partition and Soffit Framing:

1. **Steel Studs and Runners:** ASTM C 645, in depth indicated.
Minimum Base Metal Thickness: 0.0312 inch.
2. **Deep-Leg Deflection Track:** ASTM C 645 top runner with 2-inch- deep flanges.
3. **Flat Strap and Backing Plate:** Steel sheet for blocking and bracing in length and width indicated.
Minimum Base Metal Thickness: 0.0312 inch.
4. **Cold-Rolled Channel Bridging:** 0.0538-inch bare steel thickness, with minimum 1/2-inch- wide flange, and in depth indicated.
Clip Angle: 1-1/2 by 1-1/2 inch, 0.068-inch- thick, galvanized steel.
5. **Hat-Shaped, Rigid Furring Channels:** ASTM C 645, in depth indicated.
Minimum Base Metal Thickness: 0.0312 inch.
6. **Cold-Rolled Furring Channels:** 0.0538-inch bare steel thickness, with minimum 1/2-inch- wide flange, and in depth indicated.
Furring Brackets: Adjustable, corrugated-edge type of steel sheet with minimum bare steel thickness of 0.0312 inch.

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.

7 Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

2.3 PANEL PRODUCTS

- A. Panel Size, General: Provide in maximum lengths and widths available that will minimize joints in each area and correspond with support system indicated.
- B. Gypsum Wallboard: ASTM C 36/C 36 M or ASTM 1396/C, 1396M as applicable to gypsum board type indicated and whichever is more stringent.
 - 1. Moisture and Mold Resistant Type: with moisture and mold resistant core and surfaces.
 - Thickness: Provide gypsum board in thickness indicated or if not otherwise indicated ½".
 - Long Edges: Tapered
- C. Tile Backing Panels:
 - 1. Glass-Mat, Water-Resistant Backing Board: ASTM C 1178/C 1178M, with core type and in thickness indicated.
 - Product: G-P Gypsum Corp.; Dens-Shield Tile Backer.

2.4 TRIM ACCESSORIES

- A. Interior Trim: ASTM C 1047.
 - 1. Cornerbead: Use at outside corners.
 - 2. LC-Bead: Use at exposed panel edges.
 - 3. Expansion (Control) Joint: Install at continuous installations over 30 feet.

2.5 JOINT TREATMENT MATERIALS

- A. General: Comply with ASTM C 475.
- B. Joint Tape:
 - 1. Interior Gypsum Wallboard: Paper.
 - 2. Tile Backing Panels: As recommended by panel manufacturer.
- 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, flanges of trim accessories, and fasteners, use setting-type taping compound or drying-type, all-purpose compound.
 - Use setting-type compound for installing paper-faced metal trim accessories.
 - 3. Fill Coat: For second coat, use drying-type, all-purpose compound.
 - 4. Finish Coat: For third coat, use drying-type, all-purpose compound.
 - 5. Skim Coat: For final coat of Level 5 finish, use drying-type, all-purpose compound.
- D. Joint Compound for Tile Backing Panels:
 - 1. Glass-Mat, Water-Resistant Backing Panel: As recommended by manufacturer.

2.6 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.
 - 2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
- C. **Isolation Strip at Exterior Walls:**
 - 1. **Asphalt-Saturated Organic Felt:** ASTM D 226, Type I (No. 15 asphalt felt), nonperforated.
- D. **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.

PART 3 - EXECUTION

3.1 NON-LOAD-BEARING STEEL FRAMING INSTALLATION

- A. **General:** Comply with ASTM C 754, and ASTM C 840 requirements that apply to framing installation.
- B. **Suspended Ceiling and Soffit Framing:**
 - 1. Suspend ceiling 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, countersplaying, 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. Attach hangers to structural members. Do not support ceilings from or attach hangers to permanent metal forms, steel deck tabs, steel roof decks, ducts, pipes, or conduit.
 - 4. Wire-tie furring channels to supports, as required to comply with requirements for assemblies indicated.
 - 5. **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.
- C. **Partition and Soffit Framing:**
 - 1. Where studs are installed directly against exterior walls, install isolation strip between studs and wall.
 - 2. 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.
3. 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.

Install two studs at each jamb, unless otherwise indicated.
Extend jamb studs through suspended ceilings and attach to underside of floor or roof structure above.
 4. 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.
- D. Polyethylene Vapor Retarder: Install to comply with requirements specified in Division 7 Section "Building Insulation."

3.2 PANEL PRODUCT INSTALLATION

- A. Gypsum Board: Comply with ASTM C 840 and GA-216.
1. Space screws a maximum of 12 inches o.c. for vertical applications.
 2. Space fasteners in panels that are tile substrates a maximum of 8 inches o.c.
 3. On ceilings, apply gypsum panels before wall/partition board application to the greatest extent possible and at right angles to framing, unless otherwise indicated.
 4. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing), unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.

Stagger abutting end joints not less than one framing member in alternate courses of board.
At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.
 5. Single-Layer Fastening Methods: Apply gypsum panels to supports with steel drill screws.
 6. Multilayer Fastening Methods: Fasten base layers and face layers separately to supports with screws.
- B. Tie Backing Panels:
1. Glass-Mat, Water-Resistant Backing Panel: Install with 1/4-inch gap where panels abut other construction or penetrations.

3.3 FINISHING

- A. Installing Trim Accessories: 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. Finishing Gypsum Board Panels: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration.
1. Prefill open joints and damaged surface areas.
 2. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
 3. Glass-Mat, Water-Resistant Backing Panels: Finish according to manufacturer's written instructions.

- C. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840, for locations indicated:
1. Level 1: Embed tape at joints in ceiling plenum areas, concealed areas, and where indicated, unless a higher level of finish is required for fire-resistance-rated assemblies and sound-rated assemblies.
 2. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges where panels are substrate for tile.
 3. Level 4: 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.

END OF SECTION 09 29 00

SECTION 09 31 00 - CERAMIC TILE

PART 4 - GENERAL

4.1 SUMMARY

A. Section Includes:

1. Ceramic tile.

4.2 SUBMITTALS

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

B. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints.

C. Samples:

1. Each type and composition of tile and for each color and finish required.
2. Grout color samples.

4.3 EXTRA MATERIALS

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.

PART 5 - PRODUCTS

5.1 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. Tile Type CT-3: Glazed wall tile.

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. American Olean; Division of Dal-Tile International Inc.
 - b. Crossville, Inc.
 - c. Daltile; Division of Dal-Tile International Inc.
2. **Basis-of-Design Product:** Subject to compliance with requirements, provide Daltile semi-gloss or comparable product by one of the following:

- a. American Olean; Division of Dal-Tile International Inc.
 - b. Daltile; Division of Dal-Tile International Inc.
 - c. Florida Tile Industries, Inc.
3. Module Size: 3 by 6 inches.
 4. Thickness: 5/16 inch.
 5. Face: Plain with modified square edges or cushion edges.
 6. Finish: Bright, opaque glaze.
 7. Tile Color and Pattern: As selected by Architect from manufacturer's full range.
 8. Grout Color: As selected by Architect from manufacturer's full range.
 9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
 - a. Base: Coved, module size 3 by 6 inches.
 - b. Wainscot Cap: Bullnose cap, module size 3 by 6 inches.
 - c. External Corners for Thin-Set Mortar Installations: Bullnose shape, same size as adjoining flat tile.
 - d. Internal Corners: For coved base and cap use angle pieces designed to fit with stretcher shapes.

5.2 SETTING MATERIALS

A. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bonsal American; an Oldcastle company.
 - b. DAP, Inc.
 - c. Laticrete International, Inc.
 - d. MAPEI Corporation.
 - e. Southern Grouts & Mortars, Inc.
 - f. Summitville Tiles, Inc.
 - g. TEC Specialty Products Inc.
2. Prepackaged, dry-mortar mix to which only water must be added.
3. Prepackaged, dry-mortar mix combined with liquid-latex additive.
4. For wall applications, provide nonsagging mortar.

5.3 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10.

B. Standard Cement Grout: ANSI A118.6.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bonsal American; an Oldcastle company.
 - b. DAP, Inc.
 - c. Laticrete International, Inc.
 - d. MAPEI Corporation.
 - e. Southern Grouts & Mortars, Inc.
 - f. Summitville Tiles, Inc.

- g. TEC Specialty Products Inc.

5.4 MISCELLANEOUS MATERIALS

- A. Grout Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Bonsal American; an Oldcastle company.
 - b. DAP, Inc.
 - c. Laticrete International, Inc.
 - d. MAPEI Corporation.
 - e. Southern Grouts & Mortars, Inc.
 - f. Summitville Tiles, Inc.
 - g. TEC Specialty Products Inc.

PART 6 - EXECUTION

6.1 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.

6.2 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. Blending: For tile exhibiting color variations, use factory blended tile or blend tiles at Project site before installing.

6.3 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.
- 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. 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.
- E. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:
 - 1. CT-3 Glazed Wall Tile: 1/16 inch.
- F. 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 Division 07 Section "Joint Sealants."
- G. Grout Sealer: Apply grout sealer to grout joints according to grout-sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.
- H. Install cementitious backer units and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.
- I. 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.

6.4 INTERIOR TILE INSTALLATION SCHEDULE

- A. Interior Wall Installations, Metal Studs or Furring:
 - 1. Tile Installation W245: Thin-set mortar on coated glass-mat, water-resistant gypsum backer board
 - a. Tile Type: Glazed ceramic wall tile.
 - b. Thin-Set Mortar: Latex portland cement mortar.
 - c. Grout: Standard unsanded cement grout.

END OF SECTION 09 31 00

SECTION 09 51 23 - ACOUSTICAL TILE CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes acoustical tiles and concealed suspension systems for ceilings.

1.2 SUBMITTALS

- A. Product Data: For each product indicated.
- B. Coordination Drawings: Drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- C. Samples: For each acoustical tile, for each concealed suspension system member, for each exposed molding and trim, and for each color and texture required.
- D. Product test reports.
- E. Research/evaluation reports.
- F. Maintenance data.

1.3 QUALITY ASSURANCE

- A. Acoustical Testing Agency Qualifications: An independent testing laboratory or an NVLAP-accredited laboratory.
- B. Fire-Test-Response Characteristics:
 - 1. Surface-Burning Characteristics: Acoustical tiles complying with ASTM E 1264 for Class A materials, when tested per ASTM E 84.
Smoke-Developed Index: 26 or less.
- C. Seismic Standard: Comply with the following:
 - 1. CISCA's "Recommendations for direct hung acoustic tile and lay-in ceiling panel ceilings," seismic zone 0-2.

1.4 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- 1. Acoustical Ceiling Units: Full-size units equal to 2.0 percent of quantity installed, but not fewer than 2.0.
- 2. Suspension System Components: Quantity of each concealed grid and exposed component equal to 2.0 percent of quantity installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:
 - 1. Subject to compliance with requirements, provide one of the manufacturers specified.

2.2 GENERAL

- A. Acoustical Tile Standard: Comply with ASTM E 1264.
- B. Metal Suspension System Standard: Comply with ASTM C 635.
- C. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated.
- D. Wire Hangers, Braces, and Ties: Zinc-coated carbon-steel wire; ASTM A 641/A 641M, Class 1 zinc coating, soft temper.
 - 1. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- diameter wire.
- E. Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that fit acoustical tile edge details and suspension systems indicated; formed from sheet metal of same material and finish as that used for exposed flanges of suspension system runners.

2.3 ACOUSTICAL TILES

- A. Manufacturers:
 - 1. Armstrong
 - 2. Chicago Metallic
 - 3. United States Gypsum
- B. Basis of Design EGAP #1: Eclipse Climaplus
 - 1. Classification: Type III Form 1 or 2.
Pattern E1

2. Color: White
3. LR: .84
4. NRC: .65 - .75
5. CAC: 35 – 39
6. Edge Detail: SLT
7. Thickness: 3/4 inch
8. Size: 24" x 24 inch

2.4 METAL SUSPENSION SYSTEM

- A. Basis of Design: USG, Donn DX for EGAP #1
- B. Edge Detail: Shadowline Wall Angle
- C. Direct-Hung Suspension System: Intermediate-duty structural classification.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install acoustical tile ceilings to comply with ASTM C 636 and seismic requirements indicated, per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
- B. Measure each ceiling area and establish layout of acoustical tiles to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width tiles at borders.
- C. Suspend ceiling hangers from building's structural members, plumb and free from contact with insulation or other objects within ceiling plenum. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers, use trapezes or equivalent devices.
 1. Do not support ceilings directly from permanent metal forms or floor deck; anchor into concrete slabs.
 2. Do not attach hangers to steel deck tabs or to steel roof deck.
- D. Install edge moldings and trim at perimeter of acoustical tile ceiling area and where necessary to conceal edges of acoustical units. Screw attach moldings to substrate with concealed fasteners at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.
- E. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- F. Install acoustical tiles in coordination with suspension system and exposed moldings and trim. Place splines or suspension system flanges into kerfed edges so tile-to-tile joints are closed by double lap of material. Fit adjoining tile to form flush, tight joints. Scribe and cut tile for accurate fit at borders and around penetrations through tile. Hold tile field in compression by inserting leaf-type, spring-steel spacers between tile and moldings, spaced 12 inches o.c.

END OF SECTION 9 51 00

SECTION 09 66 23 - RESINOUS MATRIX TERRAZZO FLOORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thin-set, epoxy-resin terrazzo flooring.
2. Thin-set, pre-cast, epoxy-resin terrazzo wall base units.
3. Related accessories.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to terrazzo including, but not limited to, the following:
 - a. Inspect and discuss condition of substrate and other preparatory work performed by other trades.
 - b. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - c. Review special terrazzo designs and patterns.
 - d. Review dust control procedures.
 - e. Review plans for concrete curing and site drying to enable timely achievement of suitable slab moisture conditions.
 - f. Discuss allowances and any adjustments of quantities.

1.3 ACTION SUBMITTALS

A. Product Data: Manufacturer's product data for each type of terrazzo and accessory. System will be evaluated on the basis of standards. For tests not listed in published data, manufacturer shall supply missing data according to standard referenced.

1. Physical properties.
2. Performance properties.
3. Specified tests.
4. Material Safety Data Sheet.
5. Manufacturer's standard warranty.

B. Shop Drawings: Include terrazzo installation requirements. Include plans, elevations, sections, component details, and attachments to other work. Show layout of the following:

1. Divider strips.
2. Control and Expansion joint strips.

3. Accessory strips.
 4. Abrasive strips.
 5. Precast terrazzo jointing and edge configurations including anchorage details.
- C. Samples for Initial Selection: Manufacturer's color plates showing the full range of colors and patterns available for each terrazzo type indicated for colors and patterns indicated in Finish and Color Schedules.
- D. Samples for Verification: For each type, material, color, and pattern of terrazzo and accessory required showing the full range of color, texture, and pattern variations expected. Label each terrazzo sample to identify manufacturer's matrix color and aggregate types, sizes, and proportions. Prepare Samples of same thickness and from same material to be used for the Work, in size indicated below:
1. Terrazzo: 6-inch- (150-mm-) square Samples.
 2. Precast Terrazzo: 6-inch- (150-mm-) square Samples.
 3. Accessories: 6-inch- (150-mm-) long Samples of each exposed strip item required.
- E. Material Test Reports: For moisture and/or relative humidity of substrate.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Submit copies of NTMA maintenance recommendations and manufacturer's instructions in accordance with Division 01 Section "Closeout Procedures."

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Engage an installer who is a contractor member of NTMA.
 2. Engage an installer who is certified in writing by terrazzo manufacturer as qualified to install manufacturer's products.
 3. Engage a terrazzo contractor with at least five (5) years of satisfactory experience in installation of epoxy terrazzo. Terrazzo contractor shall demonstrate experience during last five (5) years of at least (5) projects of comparable scope and complexity of at least 50 percent of the total square footage of this project.
- B. Source Limitations: Obtain primary terrazzo materials from single source from single manufacturer. Provide secondary materials including patching and fill material, joint sealant, and repair materials of type and from source recommended by manufacturer of primary materials.
- C. Source Limitations for Aggregates: Obtain each color, grade, type, and variety of granular materials from single source with resources to provide materials of consistent quality in appearance and physical properties.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in supplier's original wrappings and containers, labeled with source's or manufacturer's name, material or product brand name, and lot number if any.
- B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
 - 1. Storage temperatures should be between 60°F to 80°F.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Comply with manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting terrazzo installation.
 - 1. Terrazzo contractor shall, prior to surface preparation:
 - a. Evaluate slab condition, including slab moisture content and extent of repairs required, if any.
 - b. Maintain the ambient room and floor temperature at 60°F or above for a period extending 72 hours before, during and after floor installation. Concrete to receive epoxy terrazzo shall have cured for at least 28 days and be free of all curing compounds. Test concrete substrate to determine acceptable moisture levels prior to installation. Testing should be conducted according to ASTM F2170 (determining relative humidity in concrete slabs using in situ probes).
 - c. Concrete floor shall receive a steel trowel finish.
 - d. Prior to and during each day of installation, the terrazzo contractor shall verify that the dew point is at least 5°F (-15°C) less than the slab and air temperature.
 - 2. Acceptable Substrates:
 - a. Level tolerance: Concrete sub-floor shall be level with a maximum variation from level of 1/4" in 10 feet. Any irregularity of the surface requiring patching and/or leveling shall be done epoxy modified cement and selected aggregates as recommended by epoxy flooring manufacturer.
 - b. Concrete floor shall be prepared mechanically by shot blasting or by grinding with diamond grit sanders in accordance with ICRI Guideline No. 03732. Specifically, surface preparation results should achieve a CSP3-CSP5 profile.
- B. Field Measurements: Verify actual dimensions of construction contiguous with precast terrazzo by field measurements before fabrication.
- C. Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during terrazzo installation.
- D. Close spaces to traffic during terrazzo application and for not less than 24 hours after application unless manufacturer recommends a longer period.
- E. Control and collect water and dust produced by grinding operations. Protect adjacent construction from detrimental effects of grinding operations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. **NTMA Standards:** Comply with NTMA's "Terrazzo Specifications and Design Guide" and with written recommendations for terrazzo type indicated unless more stringent requirements are specified.
- B. **FloorScore Compliance:** Terrazzo floors shall comply with requirements of FloorScore Standard.
- C. **Low-Emitting Materials:** Flooring system shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.2 EPOXY-RESIN TERRAZZO

- A. **Epoxy-Resin Terrazzo (TER):** Comply with NTMA's "Terrazzo Specifications and Design Guide" and manufacturer's written instructions for matrix and aggregate proportions and mixing.
 - 1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. Terrazzo & Marble Supply Companies; Terroxy Resin Systems.
 - b. General Polymers Corporation; Terrazzo 1100.
 - c. TEC Specialty Construction Brands, Inc.; Tuff-Lite Epoxy Terrazzo.
 - 2. **Thickness:** 3/8" (9.5 mm) nominal.
 - 3. **Formulated Mix Color and Pattern:** NTMA #S-04-27
- B. **Materials:**
 - 1. **Flexible Reinforcing Membrane:** Manufacturer's resinous membrane for substrate-crack preparation and reflective-crack reduction.
 - a. **Reinforcement:** Fiberglass scrim.
 - 2. **Primer:** Manufacturer's product recommended for substrate and use indicated.
 - 3. **Moisture Vapor Barrier Primer:** Manufacturer's product recommended for substrate and use indicated.
 - 4. **Epoxy-Resin Matrix:** Manufacturer's standard recommended for use indicated and in color required for mix indicated.
 - a. **Physical Properties without Aggregates:**
 - 1) **Hardness:** 60 to 85 per ASTM D 2240, Shore D.
 - 2) **Minimum Tensile Strength:** 3000 psi (20.7 MPa) per ASTM D 638 for a 2-inch (51-mm) specimen made using a "C" die per ASTM D 412.
 - 3) **Minimum Compressive Strength:** 10,000 psi (6.9 MPa) per ASTM D 695, Specimen B cylinder.

- 4) **Chemical Resistance:** No deleterious effects by contaminants listed below after seven-day immersion at room temperature per ASTM D 1308.
 - a) Distilled water.
 - b) Mineral oil.
 - c) Isopropanol.
 - d) Ethanol.
 - e) 0.025 percent detergent solution.
 - f) 1.0 percent soap solution.
 - g) 10 percent sodium hydroxide.
 - h) 10 percent hydrochloric acid.
 - i) 30 percent sulfuric acid.
 - j) 5 percent acetic acid.
 - b. **Physical Properties with Aggregates:** For resin blended with Georgia white marble, ground, grouted, and cured per requirements in NTMA's "Terrazzo Specifications and Design Guide"; comply with the following:
 - 1) **Flammability:** Self-extinguishing, maximum extent of burning 1/4 inch (6.35 mm) per ASTM D 635.
 - 2) **Thermal Coefficient of Linear Expansion:** 0.0025 inch/inch per deg F (0.0025 mm/mm per 0.5556 deg C) for temperature range of minus 12 to plus 140 deg F (minus 24 to plus 60 deg C) per ASTM D 696.
 - 3) **Bond Strength:** 300 psi (100% concrete failure) per ACI COMM 403 Bulletin 59-43 (pages 1139-1141).
5. **Aggregates:** Comply with NTMA gradation standards for mix indicated and contain no deleterious or foreign matter.
- a. **Abrasion and Impact Resistance:** Less than 40 percent loss per ASTM C 131.
 - b. **24-Hour Absorption Rate:** Less than 0.75 percent.
 - c. **Dust Content:** Less than 1.0 percent by weight.
 - d. **Materials:**
 - 1) Georgia White marble
 - 2) Mother of Pearl
 - 3) Glass
 - 4) Others as indicated on color schedule.
6. **Finishing Grout:** Resin based
- C. **Floor Finish and Polishing:**
1. Grind and Polish Epoxy-Resin Terrazzo up to the use of 1000 grit pads. Surface shall have a uniform reflective appearance showing no high or low sheen variances.
- 2.3 **PRECAST EPOXY-RESIN TERRAZZO**
- A. **General:** Pre-cast units shall be fabricated using the same material as the floor. Contractor is to provide and install precast units as specified.

- B. **Precast Epoxy-Resin Terrazzo Base (TRB):** Minimum 1/4-inch- (19-mm-) thick, reinforced portland cement terrazzo units cast in maximum lengths possible, but not less than 36 inches (900 mm). Comply with NTMA's written recommendations for fabricating precast terrazzo base units in sizes and profiles indicated.
1. **Type:** Coved with minimum 3/4-inch (19-mm) radius.
 2. **Top Edge:** Radius edge with polished top surface.
 3. **Metal Toe Strip:** Zinc.
 4. **Outside Corner Units:** With finished returned edges at outside corner.
 5. **Color, Pattern, and Finish:** As indicated in color and finish schedule. Match adjacent poured-in-place epoxy terrazzo flooring.

2.4 STRIP MATERIALS

- A. **Thin-Set Divider Strips:** L-type angle, 3/8 inch (6.4 mm) deep.

1. **Material:** Aluminum.
2. **Top Width:** 1/8 inch (3.2 mm).

- B. **Control-Joint Strips:** Separate double L-type angles back to back with minimum 1/8" width between. Fill joint and area between strips with semi-flexible joint filler. Match material, thickness and color of divider strips and depth required for topping thickness indicated.

- C. **Expansion-Joint Strips:** Separate double L-type angles, positioned back to back with minimum 1/8" width between. Fill area between strips with semi-flexible joint filler. Match material, thickness and color of divider strips and depth required for topping thickness indicated.

- D. **Accessory Strips:** Match divider-strip width, material, and color unless otherwise indicated. Use the following types of accessory strips as required to provide a complete installation:

1. **Base-bead strips** for exposed top edge of terrazzo base.
2. **Edge-bead strips** for exposed edges of terrazzo.

- E. **Abrasive Strips:** Three-line abrasive inserts at nosings. Silicon carbide or aluminum oxide, or combination of both, in epoxy-resin binder and set in channel.

1. **Width:** 1/2 inch (12.7 mm).
2. **Depth:** As required by terrazzo thickness.
3. **Length:** 4 inches (100 mm) less than stair width.
4. **Color:** As selected by Architect from full range of industry colors.

2.5 MISCELLANEOUS ACCESSORIES

- A. **Strip Adhesive:** Epoxy-resin adhesive recommended by adhesive manufacturer for this use.

1. **Adhesives** shall have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- B. **Anchoring Devices:**

1. Strips: Provide mechanical anchoring devices or adhesives for strip materials as recommended by manufacturer and required for secure attachment to substrate.
2. Precast Terrazzo: Provide mechanical anchoring devices as recommended by fabricator for proper anchorage and support of units for conditions of installation and support.
 - C. Patching and Fill Material: Terrazzo manufacturer's resinous product approved and recommended by manufacturer for application indicated.
 - D. Joint Compound: Terrazzo manufacturer's resinous product approved and recommended by manufacturer for application indicated.
 - E. Resinous Matrix Terrazzo Cleaner: Chemically neutral cleaner with pH factor between 7 and 10 that is biodegradable, phosphate free, and recommended by sealer manufacturer for use on terrazzo type indicated.
 - F. Sealer: (Not Required.)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and areas, 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, including levelness tolerances, have been corrected.

3.2 PREPARATION

- A. Clean substrates of substances, including oil, grease, and curing compounds, that might impair terrazzo bond. Provide clean, dry, and neutral substrate for terrazzo application.
- B. Concrete Slabs:
 1. Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with terrazzo.
 - a. Shot-blast surfaces with an apparatus that abrades the concrete surface, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
 - b. Repair damaged and deteriorated concrete according to terrazzo manufacturer's written recommendations.
 - c. Use patching and fill material to fill holes and depressions in substrates according to terrazzo manufacturer's written instructions.
 - C. Verify that concrete substrates are dry and moisture-vapor emissions are within acceptable levels according to manufacturer's written instructions.
1. Moisture Testing: Perform tests indicated below.

- a. **In-Situ Probe Test:** Perform relative-humidity test using in-situ probes per ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative-humidity-level measurement.
- D. **The use of a Moisture Vapor Retarding Primer and Crack Isolation Membranes is required. Provide 100% coverage of concrete slab to receive terrazzo finish.**
 1. **Flexible Reinforcing Membrane:**
 - a. Prepare and prefill substrate cracks with membrane material.
 - b. Reinforce membrane with fiberglass scrim according to manufacture's written instructions.
 - c. Prepare membrane according to manufacturer's written instructions before applying substrate primer.
 2. **Moisture Vapor Retarding Primer:** Apply to terrazzo substrates according to manufacturer's written instructions.
- E. **Protect other work from water and dust generated by grinding operations. Control water and dust to comply with environmental protection regulations.**
 1. **Erect and maintain temporary enclosures and other suitable methods to limit water damage and dust migration and to ensure adequate ambient temperatures and ventilation conditions during installation.**

3.3 EPOXY-RESIN TERRAZZO INSTALLATION

- A. **Comply with NTMA's written recommendations for terrazzo and accessory installation.**
- B. **Place, rough grind, grout, cure grout, fine grind, and finish terrazzo according to manufacturer's written instructions and NTMA's "Terrazzo Specifications and Design Guide."**
- C. **Installation Tolerance:** Limit variation in terrazzo surface from level to 1/4 inch in 10 feet (6.4 mm in 3 m) noncumulative.
- D. **Ensure that matrix components and fluids from grinding operations do not stain terrazzo by reacting with divider and control-joint strips.**
- E. **Delay fine grinding until heavy trade work is complete and construction traffic through area is restricted.**
- F. **Strip Materials:**
 1. **Divider and Control-Joint Strips:**
 - a. **Locate divider strips in locations indicated and as required by NTMA standards.**
 - b. **Install control-joint strips back to back directly above concrete-slab control joints.**
 - c. **Install control-joint strips with 1/4-inch (6.4-mm) gap between strips, and install sealant in gap.**
 - d. **Install strips in adhesive setting bed without voids below strips, or mechanically anchor strips as required to attach strips to substrate, as recommended by strip manufacturer.**

2. **Accessory Strips:** Install as required to provide a complete installation.

3.4 **PRECAST TERRAZZO INSTALLATION**

- A. Install precast terrazzo units using method recommended by NTMA and manufacturer unless otherwise indicated.
- B. Do not install units that are chipped, cracked, discolored, or not properly finished.
- C. Seal joints between units with joint compound matching precast terrazzo matrix.

3.5 **REPAIR**

- A. Cut out and replace terrazzo areas that evidence lack of bond with substrate. Cut out terrazzo areas in panels defined by strips and replace to match adjacent terrazzo, or repair panels according to NTMA's written recommendations, as approved by Architect.

3.6 **CLEANING AND PROTECTION**

- A. **Cleaning:**
 - 1. Remove grinding dust from installation and adjacent areas.
 - 2. Wash surfaces with cleaner according to NTMA's written recommendations and manufacturer's written instructions; rinse surfaces with water and allow them to dry thoroughly.
- B. **Sealing:**
 - 1. Not required on polished finish.
- C. **Protection:** Provide final protection and maintain conditions, in a manner acceptable to Installer, that ensure that terrazzo is without damage or deterioration at time of Substantial Completion.

END OF SECTION 09 66 23

SECTION 09 91 20 - PAINTING (PROFESSIONAL LINE PRODUCTS)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes surface preparation and field painting of exposed exterior and interior items and surfaces.

1.2 SUBMITTALS

- A. **Product Data:** For each product indicated.
- B. **Samples:** For each type of finish-coat material indicated.

1.3 QUALITY ASSURANCE

- A. **Benchmark Samples (Mockups):** Provide a full-coat benchmark finish sample for each type of coating and substrate required. Comply with procedures specified in PDCA P5.
 - 1. **Wall Surfaces:** Provide samples on at least 100 sq. ft.
 - 2. **Small Areas and Items:** Architect will designate items or areas required.
 - 3. **Final approval of colors will be from benchmark samples.**

1.4 PROJECT CONDITIONS

- A. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain storage containers in a clean condition, free of foreign materials and residue.
- B. Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 50 and 90 deg F.
- C. Apply solvent-thinned paints only when temperatures of surfaces to be painted and surrounding air are between 45 and 95 deg F.
- D. Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

1.5 EXTRA MATERIALS

- A. Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to Owner.
 - 1. Quantity: 3 percent, but not less than 1 gal. or 1 case, as appropriate, of each material and color applied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products listed in other Part 2 articles.
- B. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Benjamin Moore & Co. (Benjamin Moore).
 - 2. ICI Dulux Paint Centers (ICI Dulux Paints) (Basis of Design)
 - 3. Sherwin-Williams Co. (Sherwin-Williams).

2.2 PAINT MATERIALS, GENERAL

- A. Material Compatibility: Provide block fillers, primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
- B. Material Quality: Provide manufacturer's best-quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.
- C. Colors: As selected from manufacturer's full range.

2.3 PREPARATORY COATS

- A. Gypsum Board Primer: Factory-formulated alkali-resistant acrylic-latex interior primer for interior application.
 - 1. Benjamin Moore; Fresh Start 100% Acrylic Primer 046. Applied at a dry film thickness of not less than 1.2 mils (0.030 mm).
 - 2. ICI Dulux Paints; Gripper Multipurpose Int/Ext Water Base. Applied at a dry film thickness of not less than 1.8 mils (0.046 mm).
 - 3. Sherwin-Williams; Interior PVA Drywall Primer: Applied at a dry film thickness of not less than 3.0 mils (0.076 mm).

2.4 INTERIOR FINISH COATS

- A. Interior Low-Luster Acrylic Enamel: Factory-formulated eggshell acrylic-latex interior enamel.
1. Benjamin Moore; Moorcraft Super Spec Latex Eggshell Enamel No. 274: Applied at a dry film thickness of not less than 1.3 mils (0.033 mm).
 2. ICI Dulux Paints; 1402-XXXX Dulux Professional Acrylic Eggshell Interior Wall & Trim Enamel: Applied at a dry film thickness of not less than 1.4 mils (0.036 mm).
 3. Sherwin-Williams; ProMar 200 Interior Latex Egg-Shell Enamel B20W200 Series: Applied at a dry film thickness of not less than 1.6 mils (0.041 mm).

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with procedures specified in PDCA P4 for inspection and acceptance of surfaces to be painted.
- B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.
- C. Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.
1. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
- D. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.
1. Provide barrier coats over incompatible primers or remove and reprime.
 2. Cementitious Materials: Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.
 3. Wood: Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sand surfaces exposed to view smooth and dust off.
 - a. Scrape and clean small, dry, seasoned knots, and apply a thin coat of white shellac or other recommended knot sealer before applying primer. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.
 - b. Prime, stain, or seal wood to be painted immediately on delivery. Prime edges, ends, faces, undersides, and back sides of wood, including cabinets, counters, cases, and paneling.
 - c. If transparent finish is required, backprime with spar varnish.
 - d. Backprime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on back side.

- e. Seal tops, bottoms, and cutouts of unprimed wood doors with a heavy coat of varnish or sealer immediately on delivery.
4. **Ferrous Metals:** Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.
 - a. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
 - b. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.
5. **Galvanized Surfaces:** Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.
- E. **Material Preparation:**
 1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
 2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
- F. **Exposed Surfaces:** Include areas visible when permanent or built-in fixtures, grilles, convactor covers, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.
 1. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 2. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.
 3. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.
 4. Finish exterior doors on tops, bottoms, and side edges the same as exterior faces.
 5. Finish interior of wall and base cabinets and similar field-finished casework to match exterior.
- G. Sand lightly between each succeeding enamel or varnish coat.
- H. **Scheduling Painting:** Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
 1. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance.
- I. **Application Procedures:** Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.
- J. **Minimum Coating Thickness:** Apply paint materials no thinner than manufacturer's recommended spreading rate. Provide total dry film thickness of the entire system as recommended by manufacturer.
- K. **Mechanical and Electrical Work:** Painting of mechanical and electrical work is limited to items exposed in equipment rooms and occupied spaces.

- L. **Block Fillers:** Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled.
- M. **Prime Coats:** Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.
- N. **Pigmented (Opaque) Finishes:** Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.
- O. **Stipple Enamel Finish:** Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.

3.2 CLEANING AND PROTECTING

- A. At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from Project site.
 - B. Protect work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.
 - C. Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work.
1. After work of other trades is complete, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

3.3 INTERIOR PAINT SCHEDULE

- A. **Masonry Walls**
 1. **Acrylic Finish:** Two finish coats over a primer.
 2. **Concrete and Masonry**
 - a. **Primer:** Interior gypsum board primer.
 - b. **Finish Coats:** Interior low luster acrylic enamel.

END OF SECTION 09 91 20

SECTION 09 91 23 – HIGH PERFORMANCE CONCRETE COATINGS

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 surface preparation and application of high-performance coating systems on the following substrates:
 - 1. Interior Substrates:
 - a. Concrete, vertical & horizontal surfaces.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include preparation requirements and application instructions.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- 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. Coatings: 5 percent, but not less than 2 gal. of each material and color applied.

1.5 QUALITY ASSURANCE

- 1. Installer shall have a minimum of 5 years experience installing epoxy coatings on concrete slab on grade substrates.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

- A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 50 and 95 deg F.
- B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.
- C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 HORIZONTAL EPOXY COATINGS

- A. **Epoxy, High-Build, Low Gloss: Basis-of-Design Product:** Subject to compliance with requirements, provide a base coat of Sherwin Williams (General Polymers) 3504, body coat of Sherwin Williams (General Polymers) 3589, and final coat of Sherwin Williams (General Polymers) 4638 or comparable product by one of the following:

- 1. Devoe
- 2. Tnemec Company

2.2 VERTICAL EPOXY COATINGS

- A. **Epoxy, High-Build, Low Gloss: Basis-of-Design Product:** Subject to compliance with requirements, provide a base coat of Sherwin Williams Macropoxy 646-100, body coat of Sherwin Williams Hi-solids Polyurethane, and final coat of Sherwin Williams Hi-solids Polyurethane or comparable product by one of the following:

- 1. Devoe
- 2. Tnemec Company

2.3 HIGH-PERFORMANCE COATINGS, GENERAL

- A. **MPI Standards:** Provide products that comply with MPI standards indicated and are listed in "MPI Approved Products List."
- B. **Material Compatibility:**
 - 1. Provide materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a coating system, provide products recommended in writing by manufacturers of topcoat for use in coating system and on substrate indicated.
 - 3. Provide products of same manufacturer for each coat in a coating system.
 - 4. **VOC Content:** Products shall comply with VOC limits of authorities having jurisdiction.
- C. **Low-Emitting Materials:** Interior coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the

Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Concrete substrates:

- a. Maximum Moisture Content when measured with an electronic moisture meter shall be 12 percent.
- b. Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with application of Epoxy Coating only after substrates have maximum moisture-vapor-emission rate of slab area in 24 hours permitted by manufacturer. (less than 3lbs per 1,000 square feet.
- c. Perform plastic sheet test, ASTM D 4263. Proceed with application only after testing indicates absence of moisture in substrates.
- d. Alkalinity and Adhesion Testing: Verify that concrete substrates have pH within acceptable range. Perform tests recommended by manufacturer. Proceed with application only after substrates pass testing.

- B. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

- C. Use cleaners and degreasers recommended by Epoxy Coating manufacturer only. For example, PPG recommends using PPG DuraPrep WB for cleaning substrates prior to using their products. Contact manufacturer for further instructions for treatment of areas that have not become completely cleaned after treatment and shot-blasting.

- D. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

- C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
- 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.

3.3 APPLICATION

- A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
 - 1. Use applicators and techniques suited for coating and substrate indicated.
 - 2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 3. Coat back sides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - 4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.
- D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner will engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.
 - 1. Contractor shall touch up and restore coated surfaces damaged by testing.
 - 2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

- C. Protect work of other trades against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

3.6 INTERIOR HIGH-PERFORMANCE COATING SCHEDULE

- A. Horizontal Epoxy System Surfaces.
 - 1. Base Coat: Sherwin Williams (General Polymers) 3504 (basis of design)
 - 2. Body Coat: Sherwin Williams (General Polymers) 3589 (basis of design)
 - 3. Final Coat: Sherwin Williams (General Polymers) 4638 (basis of design)
- B. Vertical Epoxy System Surfaces.
 - 1. Base Coat: Sherwin Williams (Macropoxy) 646-100 (basis of design)
 - 2. Body Coat: Sherwin Williams (Hi-Solids) Polyurethane (basis of design)
 - 3. Final Coat: Sherwin Williams (Hi-Solids) Polyurethane (basis of design)

END OF SECTION 09 91 23

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- ##### A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- ##### B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- ##### C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- ##### D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

2.2 SLEEVE-SEAL SYSTEMS

- ##### A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 2. Pressure Plates: Carbon steel.
 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:

- a. **Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.**
- 2. **Concrete Slabs-on-Grade:**
 - a. **Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.**
 - 1) **Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.**
- 3. **Concrete Slabs above Grade:**
 - a. **Piping Smaller Than NPS 6: PVC-pipe sleeves.**
- 4. **Interior Partitions:**
 - a. **Piping Smaller Than NPS 6: PVC-pipe sleeves.**

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.2 SUBMITTALS

- A. Product Data: For each type of valve indicated.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
- B. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
1. Handwheel: For valves other than quarter-turn types.

- E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- F. Valve-End Connections:
 - 1. Solder Joint: With sockets according to ASME B16.18.
 - 2. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE or TFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.

3.2 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball valves.
2. Throttling Service: Ball valves.
3. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

3.4 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with bronze trim.
3. Bronze Swing Check Valves: Class 125, nonmetallic disc.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Pipe positioning systems.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 PIPE POSITIONING SYSTEMS

- A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- C. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- F. Insulated Piping:
 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 4. Shield Dimensions for Pipe: Not less than the following:

- a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

3.2 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.3 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 2. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- K. Saddles: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

- L. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.

1.2 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. **Material and Thickness:** Multilayer, multicolor, plastic labels for mechanical engraving, thick, and having predrilled holes for attachment hardware.
2. **Maximum Temperature:** Able to withstand temperatures up to 160 deg F.
3. **Minimum Label Size:** Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
4. **Fasteners:** Stainless-steel rivets or self-tapping screws.
5. **Adhesive:** Contact-type permanent adhesive, compatible with label and with substrate.

- ##### B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 PIPE LABELS

- ##### A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

- ##### B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to [partially cover] [cover full] circumference of pipe and to attach to pipe without fasteners or adhesive.

- ##### C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. **Flow-Direction Arrows:** Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. **Lettering Size:** At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

- A. **Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.**

3.2 EQUIPMENT LABEL INSTALLATION

- A. **Install or permanently fasten labels on each major item of mechanical equipment.**
- B. **Locate equipment labels where accessible and visible.**

3.3 PIPE LABEL INSTALLATION

- A. **Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:**
 1. **Near each valve and control device.**
 2. **Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.**
 3. **Near penetrations through walls, floors, ceilings, and inaccessible enclosures.**
 4. **At access doors, manholes, and similar access points that permit view of concealed piping.**
 5. **Near major equipment items and other points of origination and termination.**
 6. **Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.**
 7. **On piping above removable acoustical ceilings. Omit intermediately spaced labels.**

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic hot-water piping.
2. Domestic cold-water piping

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
- B. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.4 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.5 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers, for accessible fixtures:

1. **Description:** Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 PREPARATION

- A. **Surface Preparation:** Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. **Mix insulating cements with clean potable water;** if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. **Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.**
- B. **Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.**
- C. **Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.**
- D. **Install insulation with longitudinal seams at top and bottom of horizontal runs.**
- E. **Install multiple layers of insulation with longitudinal and end seams staggered.**
- F. **Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.**
- G. **Keep insulation materials dry during application and finishing.**
- H. **Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.**
- I. **Install insulation with least number of joints practical.**
- J. **Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.**
 1. **Install insulation continuously through hangers and around anchor attachments.**

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
Install insulation continuously through walls and partitions.

B. Insulation Installation at Floor Penetrations:

1. **Pipe:** Install insulation continuously through floor penetrations.

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, and Unions:

1. Install insulation over fittings, valves, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
7. Label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.5 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of threaded valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.**

3.7 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.**

- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:**

1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.8 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot, Cold Water: Insulation shall be the following:

1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

END OF SECTION 220719

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
 1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
 2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2.3 PIPING JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- B. **Brazing Filler Metals:** AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 TRANSITION FITTINGS

- A. **Fitting-Type Transition Couplings:** Manufactured piping coupling or specified piping system fitting.
- B. **Sleeve-Type Transition Coupling:** AWWA C219.
- C. **Plastic-to-Metal Transition Fittings:**
 - 1. **Description:** CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.
- D. **Plastic-to-Metal Transition Unions:**
 - 1. **Description:** CPVC or PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install shutoff valve, hose-end drain valve, inside the building at domestic water service entrance. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for drain valves.
- D. Install domestic water piping level without pitch and plumb.
- E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- H. Install piping adjacent to equipment and specialties to allow service and maintenance.

- I. Install piping to permit valve servicing.
- J. Install unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
- K. Install piping free of sags and bends.
- L. Install fittings for changes in direction and branch connections.
- M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- N. Install thermostat in hot-water circulation piping whether shown on the drawings or not.
- O. Install sleeves for piping penetrations of walls, ceilings, and floors.
- P. Install sleeve seals for piping penetrations of concrete walls and slabs.
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.2 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.3 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.
- B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves.
- C. Install drain valves for equipment at low points in horizontal piping, and where required to drain water piping.
 - 1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
- D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball

valves for piping NPS 2 and smaller. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

3.4 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. NPS 1-1/2 and Smaller: Fitting-type coupling.
 - 2. NPS 2 and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
- E. Install supports for vertical copper tubing every 10 feet.
- F. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.

- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Piping Inspections:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- C. Piping Tests:
 - 1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow standing for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 6. Prepare reports for tests and for corrective action required.
- D. Domestic water piping will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow standing for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow standing for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.10 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Aboveground domestic water piping:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and brazed joints.

3.11 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 1. Shutoff Duty: Use ball valves.
 2. Throttling Duty: Use ball valves.
 3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Wall hydrants.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:

1. Standard: ASSE 1001.
2. Body: Bronze, nonremovable, with manual drain.

3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
4. Finish: Chrome or nickel plated.

2.2 WALL HYDRANTS

A. Nonfreeze Wall Hydrants WH1:

1. Standard: ASME A112.21.3M for exposed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Nozzle and Wall-Plate Finish: Polished nickel bronze.
9. Operating Keys(s): One with each wall hydrant.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.2 FIELD QUALITY CONTROL

- A. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

END OF SECTION 221119

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.

1.2 PERFORMANCE REQUIREMENTS

- ##### A. Seismic Performance:
- Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.3 SUBMITTALS

- ##### A. Product Data:
- For each type of product indicated.
- ##### B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- ##### A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- ##### B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- ##### A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 PVC PIPE AND FITTINGS

- ##### A. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- C. Adhesive Primer: ASTM F 656.
- D. Solvent Cement: ASTM D 2564.

2.3 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- I. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
 - J. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
 - K. Install underground PVC piping according to ASTM D 2321.
 - L. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."
 - 2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
 - M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - N. Install sleeves for piping penetrations of walls, ceilings, and floors.
 - O. Install sleeve seals for piping penetrations of concrete walls and slabs.
 - P. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- 3.2 JOINT CONSTRUCTION
- A. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.
- 3.3 SPECIALTY PIPE FITTING INSTALLATION
- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in OD's.
 - 2. In Drainage Piping: Non-pressure transition couplings.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 4. Install individual, straight, horizontal piping runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 - 2. NPS 3: 48 inches with 1/2-inch rod.
 - 3. NPS 4: 48 inches with 5/8-inch rod.
- F. Install supports for vertical PVC piping every 48 inches.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Comply with requirements for cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.6 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 - 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 6. Prepare reports for tests and required corrective action.

3.8 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.

- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.9 PIPING SCHEDULE

- A. Underground, aboveground vent, soil and waste piping shall be Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints

END OF SECTION 221316

SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermostat-control, electric, tankless, domestic-water heaters.

1.2 ACTION SUBMITTALS

- ##### A. Product Data: For each type and size of domestic-water heater indicated.

1.3 INFORMATIONAL SUBMITTALS

- ##### A. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- ##### B. Source quality-control reports.
- ##### C. Field quality-control reports.
- ##### D. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

- ##### A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- ##### A. 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.
- ##### B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- ##### C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- ##### D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Electric, Tankless, Domestic-Water Heaters: One year(s).

PART 2 - PRODUCTS

2.1 ELECTRIC, TANKLESS, domestic-WATER HEATERS

A. Thermostat-Control, Electric, Tankless, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Bosch Water Heating.
- b. Chronomite Laboratories, Inc.
- c. E-Tankless Water Heaters Corp.

3. Standard: UL 499 for electric, tankless, (domestic-water heater) heating appliance.

4. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.

- a. Connections: ASME B1.20.1 pipe thread.
- b. Pressure Rating: 150 psig.
- c. Heating Element: Resistance heating system.
- d. Temperature Control: Thermostat.
- e. Safety Control: High-temperature-limit cutoff device or system.
- f. Jacket: Aluminum or steel with enameled finish or plastic.

5. Support: Bracket for wall mounting.

6. Capacity and Characteristics:

a. Refer to schedule on design drawings.

B. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.2 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

- B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 18 inches above floor on wall bracket.
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Anchor domestic-water heaters to substrate.
- B. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- C. Fill electric, domestic-water heaters with water.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. **Manufacturer's Field Service:** Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - 2. **Leak Test:** After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. **Operational Test:** After electrical circuitry has been energized, start units to confirm proper operation.
 - 4. **Test and adjust controls and safeties.** Replace damaged and malfunctioning controls and equipment.

- B. **Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.**

- C. **Prepare test and inspection reports.**

END OF SECTION 223300

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water closets.
2. Toilet seats.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets and trim WC1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Standard America.
 - b. Crane Plumbing, L.L.C.
 - c. Zurn Industries, LLC; Commercial Brass and Fixtures.
 - d. Bemis Manufacturing Company.
 - e. Church Seats.
 - f. Olsonite Seat Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.

B. Install toilet seats on water closets.

C. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.

D. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Division 07 Section "Joint Sealants."

3.2 CONNECTIONS

- #### **A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.**

- #### **B. Comply with water piping requirements specified in Division 22 Section "Domestic Water Piping."**

- #### **C. Comply with soil and waste piping requirements specified in Division 22 Section "Sanitary Waste and Vent Piping."**

- #### **D. Where installing piping adjacent to water closets, allow space for service and maintenance.**

3.3 ADJUSTING

- #### **A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.**

3.4 CLEANING AND PROTECTION

- #### **A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.**

- #### **B. Install protective covering for installed water closets and fittings.**

- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LAVATORIES

A. Lavatory, faucet, trim LAV1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Kohler Co.
 - b. American Standard.
 - c. Crane

2.2 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.

- C. **Supply Piping:** Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
- D. **Supply Stops:** Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. **Operation:** Loose key.
- F. **Risers:**
 - 1. NPS 3/8.
 - 2. ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

2.3 WASTE FITTINGS

- A. **Standard:** ASME A112.18.2/CSA B125.2.
- B. **Drain:** Grid type with NPS 1-1/4 offset and straight tailpiece.
- C. **Trap:**
 - 1. **Size:** NPS 1-1/2 by NPS 1-1/4.
 - 2. **Material:** Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. **Examine roughing-in** of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.
- B. **Examine walls** for suitable conditions where lavatories will be installed.
- C. **Proceed with installation** only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. **Install lavatories level and plumb** according to roughing-in drawings.
- B. **Install supports, affixed to building substrate,** for wall-mounted lavatories.
- C. **Install accessible wall-mounted lavatories** at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. **Install wall flanges or escutcheons** at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

- E. Seal joints between lavatories and counters and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Division 07 Section "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Division 22 Section "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Division 22 Section "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Division 22 Section "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- B. Provide protective covering for installed lavatories and fittings.
- C. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Equipment supports.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel stainless steel.

2.2 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.
- C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.4 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- D. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- F. Install lateral bracing with pipe hangers and supports to prevent swaying.
- G. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

- H. **Pipe Slopes:** Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- I. **Insulated Piping:**
 - 1. **Attach clamps and spacers to piping.**
 - a. **Piping Operating above Ambient Air Temperature:** Clamp may project through insulation.
 - b. **Piping Operating below Ambient Air Temperature:** Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. **Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.**
 - 2. **Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.**
 - 3. **Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.**
 - 4. **Shield Dimensions for Pipe: Not less than the following:**
 - a. **12 inches long and 0.048 inch thick.**
 - 5. **Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.**

3.2 EQUIPMENT SUPPORTS

- A. **Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.**
- B. **Provide lateral bracing, to prevent swaying, for equipment supports.**

3.3 METAL FABRICATIONS

- A. **Cut, drill, and fit miscellaneous metal fabrications for equipment supports.**
- B. **Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.**
- C. **Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and 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. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- L. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.

1.2 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. **Material and Thickness:** Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. **Maximum Temperature:** Able to withstand temperatures up to 160 deg F.
3. **Minimum Label Size:** Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
4. **Minimum Letter Size:** 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. **Fasteners:** Stainless-steel rivets or self-tapping screws.
6. **Adhesive:** Contact-type permanent adhesive, compatible with label and with substrate.

- ##### B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 PIPE LABELS

- ##### A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- ##### B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- ##### C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 25 feet.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule:
 - 1. Refrigerant Piping:
 - 2. Condensate Piping:

END OF SECTION 230553

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, return.
4. Indoor, exhaust.

B. Related Sections:

1. Division 23 Section "HVAC Piping Insulation."

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.

2.4 SEALANTS

- A. FSK Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 4. Color: Aluminum.

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.6 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 6.5 mils.

3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.7 SECUREMENTS

- A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Insulation Pins and Hangers:
 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.8 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. **Surface Preparation:** Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. **Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.**
- B. **Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.**
- C. **Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.**
- D. **Install insulation with longitudinal seams at top and bottom of horizontal runs.**
- E. **Install multiple layers of insulation with longitudinal and end seams staggered.**
- F. **Keep insulation materials dry during application and finishing.**
- G. **Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.**
- H. **Install insulation with least number of joints practical.**
- I. **Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.**
 - 1. **Install insulation continuously through hangers and around anchor attachments.**
 - 2. **For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.**
 - 3. **Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.**
- J. **Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.**
- K. **Install insulation with factory-applied jackets as follows:**
 - 1. **Draw jacket tight and smooth.**

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- B. Insulation Installation at Floor Penetrations:
 1. Duct: Install insulation continuously through floor.

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

- b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.

3.6 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 1. Indoor, concealed supply and outdoor air.
 2. Indoor, exposed supply and outdoor air.
 3. Indoor, return.
 4. Indoor, exhaust.
- B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Flexible connectors.
5. Factory-insulated access panels and doors.

3.7 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, Supply-Air, Return-Air, Exhaust-Air and Outdoor-Air Duct and Plenum Insulation, Attic: Mineral-fiber blanket, 3 inches thick and 0.75-lb/cu. ft. nominal density.
- B. Concealed, Supply-Air, Return-Air, Exhaust-Air and Outdoor-Air Duct and Plenum Insulation, Non-Attic: Mineral-fiber blanket, 2 inches thick and 0.75-lb/cu. ft. nominal density.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Refrigerant suction and hot-gas piping, indoors and outdoors.
 - 2. Condensate piping, indoors.
- B. Related Sections:
 - 1. Division 23 Section "Duct Insulation."

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- B. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2.3 SEALANTS

- A. Joint Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Permanently flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 100 to plus 300 deg F.
 - 4. Color: White or gray.

2.4 TAPES

- A. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.

2.5 SECUREMENTS

- A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Keep insulation materials dry during application and finishing.
- F. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- G. Install insulation with least number of joints practical.
- H. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- J. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- K. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- L. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 3. Seal jacket to wall flashing with flashing sealant.

- B. **Insulation Installation at Interior Wall, Partition Penetrations and Floor Penetrations (That Are Not Fire Rated):** Install insulation continuously through.

3.4 **INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

- A. **Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.**
- B. **Insulation Installation on Pipe Fittings and Elbows:**
 - 1. **Install mitered sections of pipe insulation.**
 - 2. **Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.**
- C. **Insulation Installation on Pipe Specialties:**
 - 1. **Secure insulation to specialties and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.**

3.5 **FIELD QUALITY CONTROL**

- A. **Perform tests and inspections.**
- B. **All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.**

3.6 **PIPING INSULATION SCHEDULE, GENERAL**

- A. **Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.**

3.7 **INDOOR PIPING INSULATION SCHEDULE**

- A. **Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.**
- B. **Condensate Piping: Flexible elastomeric, 1 inch thick.**

3.8 **OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

- A. **Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.**

END OF SECTION 230719

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.4 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - 1. Thermostatic expansion valves.
 - 2. Filter dryers.
- B. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8.

2.2 VALVES AND SPECIALTIES

- A. Thermostatic Expansion Valves: Comply with ARI 750.
 - 1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 - 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 - 3. Packing and Gaskets: Non-asbestos.
 - 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 - 5. Suction Temperature: 40 deg F.
 - 6. Superheat: Adjustable.
 - 7. Reverse-flow option (for heat-pump applications).
 - 8. End Connections: Socket, flare, or threaded union.
 - 9. Working Pressure Rating: 700 psig.
- B. Moisture/Liquid Indicators:
 - 1. Body: Forged brass.
 - 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 - 3. Indicator: Color coded to show moisture content in ppm.
 - 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 - 5. End Connections: Socket or flare.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 240 deg F.

- C. Permanent Filter Dryers: Comply with ARI 730.
 - 1. Body and Cover: Painted-steel shell.
 - 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - 3. Designed for reverse flow (for heat-pump applications).
 - 4. End Connections: Socket.
 - 5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 - 6. Maximum Pressure Loss: 2 psig.
 - 7. Working Pressure Rating: 500 psig.
 - 8. Maximum Operating Temperature: 240 deg F.

2.3 REFRIGERANTS

- A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 1-1/2 for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- B. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- N. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- O. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BA_g, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. Maximum span, 60 inches; minimum rod size, 1/4 inch.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

- 1. Install core in filter dryers after leak test but before evacuation.**
- 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.**
- 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.**
- 4. Charge system with a new filter-dryer core in charging line.**

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.**
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.**
- C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.**
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:**
 - 1. Verify that compressor oil level is correct.**
 - 2. Open compressor suction and discharge valves.**
 - 3. Open refrigerant valves except bypass valves that are used for other purposes.**
 - 4. Check open compressor-motor alignment and verify lubrication for motors and bearings.**

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, turning vanes, and flexible ducts.

1.2 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

- ##### A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- ##### B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- ##### C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.

2.4 SEALANT AND GASKETS

- A. **General Sealant and Gasket Requirements:** Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. **Water-Based Joint and Seam Sealant:**
 - 1. **Application Method:** Brush on.
 - 2. **Solids Content:** Minimum 65 percent.
 - 3. **Shore A Hardness:** Minimum 20.
 - 4. **Water resistant.**
 - 5. **Mold and mildew resistant.**
 - 6. **VOC:** Maximum 75 g/L (less water).
 - 7. **Maximum Static-Pressure Class:** 10-inch wg, positive and negative.
 - 8. **Service:** Indoor or outdoor.
 - 9. **Substrate:** Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. **Flanged Joint Sealant:** Comply with ASTM C 920.
 - 1. **General:** Single-component, acid-curing, silicone, elastomeric.
 - 2. **Type:** S.
 - 3. **Grade:** NS.
 - 4. **Class:** 25.
 - 5. **Use:** O.
- D. **Flange Gaskets:** Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- E. **Round Duct Joint O-Ring Seals:**
 - 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

- A. **Hanger Rods for Noncorrosive Environments:** Cadmium-plated steel rods and nuts.
- B. **Hanger Rods for Corrosive Environments:** Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. **Strap and Rod Sizes:** Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. **Steel Cables for Galvanized-Steel Ducts:** Galvanized steel complying with ASTM A 603.

- E. **Steel Cable End Connections:** Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- F. **Duct Attachments:** Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- G. **Trapeze and Riser Supports:**
 - 1. **Supports for Galvanized-Steel Ducts:** Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. **Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.**
- B. **Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.**
- C. **Install round ducts in maximum practical lengths.**
- D. **Install ducts with fewest possible joints.**
- E. **Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.**
- F. **Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.**
- G. **Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.**
- H. **Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.**
- I. **Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.**
- J. **Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.**
- K. **Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 7. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 - 9. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 10. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- E. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT CLEANING

- A. Clean duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, ~~duct liner~~, or duct accessories.
4. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
5. Provide drainage and cleanup for wash-down procedures.
6. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.7 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.8 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles ~~and that do not have duct liner~~. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.9 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Constant-Volume Air-Handling Units:

- a. Pressure Class: Positive 2-inch wg.

B. Return Ducts:

1. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 2-inch wg.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

- a. Pressure Class: Negative 2-inch wg.
- D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
- 1. Ducts Connected to Air-Handling Units <Insert equipment>:
 - a. Pressure Class: Positive or negative 2-inch wg.
- E. Elbow Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- F. Branch Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
 - 2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Manual volume dampers.
 2. Turning vanes.
 3. Flexible connectors.
 4. Flexible ducts.
 5. Duct accessory hardware.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90.
 2. Exposed-Surface Finish: Mill phosphatized.

2.2 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
5. Blade Axles: Galvanized steel.
6. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 TURNING VANES

- A. **Manufactured Turning Vanes for Metal Ducts:** Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- B. **General Requirements:** Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. **Vane Construction:** Single wall.

- D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.4 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd..
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.

2.5 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10 to plus 160 deg F.
 - 4. Insulation R-value, Attic: 8.
 - 5. Insulation R-value, Non-Attic: 6.
- B. Flexible Duct Connectors:
 - 1. Clamps: Nylon strap in sizes 3 through 18 inches, to suit duct size.
 - 2. Non-Clamp Connectors: Liquid adhesive plus tape.

2.6 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts.
- C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install flexible connectors to connect ducts to equipment.
- F. Connect diffusers boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- G. Connect flexible ducts to metal ducts with per drawing details.
- H. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ceiling-mounted ventilators.

1.2 SUBMITTALS

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

B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. 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

2.1 CEILING-MOUNTED VENTILATORS

A. Housing: Steel, lined with acoustical insulation.

B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

C. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.

D. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

E. Accessories:

1. Variable-Speed Controller: Unit-mounted solid-state control to reduce speed from 100 to less than 50 percent.
2. Isolation: Rubber-in-shear vibration isolators.

F. Capacities and Characteristics:

1. As indicated on plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch.
- B. Install units with clearances for service and maintenance.
- C. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Remove and replace malfunctioning units and retest as specified above.

3.4 ADJUSTING

- A. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diffusers, register and grilles.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for volume-control dampers not integral to diffusers, registers, and grilles.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 Inlets and Outlets

A. Diffusers, Registers and Grilles:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. METALAIRE, Inc.
 - b. Price Industries.
 - c. Krueger.

2.2 SOURCE QUALITY CONTROL

- ##### A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: 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.
- C. Operation and maintenance data.
- D. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

- A. 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.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: One year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR UNITS/OUTDOOR UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Mitsubishi Electric & Electronics USA, Inc., HVAC Advanced Products Division.
 - 2. SANYO North America Corporation; SANYO Fisher Company.
 - 3. LG.

2.2 ACCESSORIES

- A. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

2.3 CAPACITIES AND CHARACTERISTICS

- A. Refer design drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install unit(s) level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts" Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

B. Tests and Inspections:

1. **Leak Test:** After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. **Operational Test:** After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. **Test and adjust controls and safeties.** Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

END OF SECTION 238126

SECTION 260500 - GENERAL ELECTRICAL

PART 1 GENERAL

1.1 SCOPE OF WORK

- A. The Instructions to Bidders, General Conditions of the Contract, Supplementary General Conditions and Division 1 bound herewith are a component part of this Division of the specifications and shall apply to this Division with equal force and shall be consulted in detail for instructions pertaining to the work.
- B. Furnish all labor, materials and equipment and incidentals required to make ready for use complete electrical systems as shown on the Drawings and specified herein.
- C. It is the intent of these Specifications that the electrical systems shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Division shall be furnished at no extra cost.
- D. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for all the proper functioning of the system and equipment. All work shall be of the highest quality; substandard work will be rejected.

1.2 SUBMITTALS

- A. Shop drawings shall be submitted for all equipment, apparatus, and other items as required by the Architect/Engineer. Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.
- B. All shop drawings and submittals shall be submitted at the same time. Partial shop drawing and submittals will be rejected and not processed. Materials, equipment and long lead items that require special handling, if identified and requested by the contractor, will be processed separately.
- C. Proposed equipment and/or materials substitutions shall be clearly indicated in shop drawings. All deviations from the specified quality, functionality, appearance or performance of the proposed equipment and/or materials shall be clearly summarized in the preface of each submittal.
- D. The project shall be bid based on the equipment listed in these specifications and on the drawings. After award of the Electrical Contract the Contractor may wish to substitute equipment other than that specified, subject to approval. The Electrical Contractor shall bear the "burden of proof" for demonstrating substitute equipment equivalency and suitability
- E. The Electrical Contractor shall be required to replace installed "equivalent" equipment if the operation of this equipment does not meet the full design intent of the specified system.

- F Physical size of equipment used in the design layout are those of reputable equipment manufacturers. The Contractor is responsible for providing equipment which will fit the space provided. If the Contractor elects to use other manufacturer's equipment, any resulting conflicts with space clearance or codes shall be the responsibility of the Contractor to correct at the Contractor's expense.

1.3 COORDINATION OF WORK

- A. The Contractor shall compare the electrical drawings and specifications with the drawings and specifications for other trades, and shall report any discrepancies between them to the Architect/Engineer and obtain written instructions for changes necessary in the electrical work. The electrical work shall be installed in cooperation with other trades installing interrelated work. Before installation, the Contractor shall make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor caused by neglect to do so shall be made at the expense of the Contractor.
- B. Location of electrical raceways, switches, panels, equipment, fixtures, etc., shall be adjusted to accommodate the work to interferences anticipated and encountered. The Contractor shall determine the exact route and location of each electrical raceway prior to make up and assembly.
 - 1. Right of Way: Lines which pitch shall have the right of way over those which do not pitch. For example, steam, condensate and plumbing drains shall normally have right of way. Lines whose elevations cannot be changed shall have the right of way over lines whose elevations can be changed.
 - 2. Offsets and changes in direction of electrical raceways shall be made as required to maintain proper headroom and to clear pitched lines whether or not indicated on the drawings. The Contractor shall furnish and install elbows, pull boxes, etc., as required to affect these offsets, transitions, and changes in directions. Conflicts between electrical raceways, fixtures, etc., and ductwork or piping which cannot be resolved otherwise, will be resolved by the Architect/Engineer.
- C. Installation and Arrangements: The Contractor shall install all electrical work to permit removal (without damage to other parts) of any equipment requiring periodic replacement or maintenance. The Contractor shall arrange electrical raceways and equipment to permit ready access to valves, cocks, traps, starters, motors, control components, etc., and to clear the opening of swinging and overhead doors and of access panels.

1.4 EQUIPMENT AND MATERIALS (GENERAL)

- A. In compliance with North Carolina General Statute 133.3, the Architect/Engineer has, wherever possible, specified the required performance and design characteristics of all materials utilized in this construction. In some cases it is impossible to specify the required performance and design characteristics and when this occurs the Architect/Engineer has specified three or more examples of equal design or equivalent design, establishing an acceptable range for items of equal or equivalent design. Cited examples are used only to denote the quality standard of product desired and do not restrict bidders to a specific brand, make, manufacturer or specific name and are used

only to set forth and convey to bidders the general style, type, character and quality of product desired. Equivalent products will be acceptable.

- B. Substitution of materials, items, or equipment of equal or equivalent design shall be submitted to the Architect/Engineer for approval or disapproval. Equal or equivalent shall be interpreted to mean an item of material or equipment, similar to that named and which is suitable for the same use and capable of performing the same functions as that named, the Architect/Engineer being the judge of equality
- C. The materials used in all systems shall be new, unused and as hereinafter specified and shall bear the manufacturer's name, trade name and third party testing agency label in every case where a standard has been established for the particular material. Equipment furnished under this specification shall be essentially the standard product of manufacturers regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for approval as required by the Architect/Engineer.
- D. Protection: Electrical equipment shall at all times during construction be adequately protected against damage. Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury and theft. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry, permanent shelters. If an apparatus has been damaged, such damage shall be repaired at no additional cost. If any apparatus has been subject to possible injury by water, it shall be replaced at no additional cost to the Owner. At the completion of the work, fixtures, equipment, and materials shall be cleaned and polished thoroughly and turned over to the Owner in a condition satisfactory to the Architect/Engineer. Damage or defects, developing before acceptance of the work shall be made good at the Contractor's expense.
- E. Any damage to factory applied paint finish shall be repaired using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted per the field painting specifications in Division 9, at no additional cost to the Owner.
- F. Where materials such as wiring devices and plates, fire alarm equipment, paging system components, etc. are specified to match existing, provide materials to match existing equipment in finish, color, capacity, ratings, operating characteristics, performance, etc.
- G. Delivery and Storage: Equipment and materials shall be delivered to the site and stored in original containers, suitably sheltered from the elements, but readily accessible for inspection by the Architect/Engineer until installed.
- H. Equipment and materials of the same general type shall be of the same make throughout the work to provide uniform appearance, operation and maintenance.
- I. Manufacturer's directions shall be followed completely in the delivery, storage, protection, and installation of all equipment and materials. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflicts between any requirements of the Contract Documents and the manufacturer's directions and shall obtain the Architect/Engineer's written instructions before proceeding with the work. Should the Contractor perform any work that does not comply with the manufacturer's direction or

such written instructions from the Architect/Engineer, the Contractor shall bear all costs arising in correcting the deficiencies.

1.5 OPERATION AND MAINTENANCE MANUALS

- A. Submit under relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.
- B. The Contractor shall provide two compilations of catalog data, bound in suitable loose leaf binders, for each manufactured item of equipment used in the electrical work. These shall be presented to the Architect/Engineer for transmittal to the Owner before the final inspection is made. Data shall include printed installation, operation and maintenance instructions for each item, indexed by product with heavy sheet dividers and tabs. All warranties shall be included with each item. Each manufacturer's name, address and telephone number shall be clearly indicated.
- C. Shop drawings with Architect/Engineer's "as noted" markings are not acceptable for the above. "Approved" shop drawings are acceptable if adequate information is contained therein. Generally, shop drawings alone are not adequate.

1.6 LOCATIONS AND MEASUREMENTS

Outlets and appliances are shown and located on the drawings as accurately as possible. All measurements shall be verified on the project and in all cases the work shall suit the surrounding trim, finishes and/or construction. The locations of outlets for special appliances shall be installed so that when extended, they are flush with the finished wall or ceiling and permit the proper installation of fixtures and/or devices. Heights of all outlets shown on the drawings are approximate only. Slight relocations of outlets, devices and equipment shall be made by the Contractor as required or as directed by the Architect/Engineer at no additional cost to the Owner.

1.7 QUALITY OF WORK

All work shall be executed as required by this specification and the accompanying drawings and shall be done by skilled mechanics, and shall present a neat, trim, and mechanical appearance when completed. All work shall be performed as required by the progress of the job.

1.8 SUPERVISION

- A. The Contractor shall personally, or through an authorized and competent representative, constantly supervise the work from the beginning to completion and final acceptance. So far as possible, the Contractor shall keep the same foreman and mechanics throughout the project duration.
- B. During the progress of the work it shall be subject to inspection by representatives of the Architect/Engineer, the Owner, and local inspection authorities, at which time the Contractor shall furnish such required information and data on the project as requested.
- C. The Electrical Contractor shall coordinate the electrical work with other Contractors and cooperate in the preparation and maintenance of a master schedule for the completion of the project.

1.9 CLOSING IN WORK

Work shall not be covered up or enclosed until it has been inspected, tested and approved by the authorities having jurisdiction over this work. Should any of the work be enclosed or covered up before such inspection and test, the Contractor shall uncover the work at the Contractor's expense; after it has been inspected, tested and approved, the Contractor shall restore the work to its original condition.

1.10 REFERENCE STANDARDS

A. All electrical equipment, materials, and installation shall be in accordance with the latest edition of the following codes and standards:

1. American Association of Edison Illuminating Companies (AEIC)
2. American National Standards Institute (ANSI)
3. American Society for Testing and Materials (ASTM)
4. Building Officials Code Administrators (BOCA)
5. Energy Code 90.1 (ASHRAE/IES)
6. Institute of Electrical and Electronic Engineers (IEEE)
7. Insulated Cable Engineers Association (ICEA)
8. International Code Council (ICC)
9. International Conference of Building Officials (ICBO)
10. National Electrical Code (NEC) 2008 edition
11. National Electrical Contractor's Association (NECA)
12. National Electrical Installation Standards (NEIS)
13. National Electrical Manufacturer's Association (NEMA)
14. National Electrical Safety Code (NESC)
15. National Fire Protection Association (NFPA)
16. North Carolina State Building Code (NCSBC)
17. North Carolina Construction Manual with GS as listed (NCCM)
18. Occupational Safety and Health Act (OSHA)
19. Requirements of the Americans with Disabilities Act (ADA), latest edition.
20. Underwriters Laboratories Inc (U.L.)
21. Southern Building Code Congress International (SBCCI)
22. Toxicity Characteristics Leaching Procedure (TCLP)

B. All electrical equipment and material shall be listed by an approved third party testing agency approved by the NCBC and shall bear the appropriate testing agency's listing mark or classification marking. Equipment, materials, etc. utilized not bearing a third party testing agency certification shall be field or factory third party testing agency certified prior to equipment acceptance and use.

C. Where reference is made to one of the above standards, the revision in effect at the time of the bid opening shall apply

1.11 ENCLOSURE TYPES

Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:

1. NEMA 1 for dry, indoor locations.

2. NEMA 3R for outdoor locations, rooms below grade (including basements and buried vaults), "DAMP" and "WET" locations.
3. NEMA 4X for locations subject to corrosion.

1.12 CODES, INSPECTION AND FEES

- A. All equipment, materials and installation shall be in accordance with the requirements of the local authority having jurisdiction.
- B. The Electrical Contractor shall obtain all necessary permits and pay all fees required for permits and inspections of electrical work.
- C. The Electrical Contractor shall contact Code Officials to schedule any and all required inspections.

1.13 TESTS AND SETTINGS

- A. Test all systems furnished under Division 26 and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.
- B. Make the following minimum tests and checks prior to energizing electrical equipment:
 1. Mechanical inspection, testing and settings of all circuit breakers, disconnect switches, motor starters, control equipment, etc., for proper operation.
 2. Check all wire and cable terminations. Verify to the Architect/Engineer that connections meet the equipment torque requirements.
 3. Check rotation of motors, obtain permission from other contractors to start motor, and proceed to check for proper rotation. If the motor rotates in the wrong direction, correct it. Take all necessary precautions not to damage any equipment.
 4. Provide all instruments and equipment for the tests specified herein.
- C. All testing shall be scheduled and coordinated by the Contractor. Notify the Owner at least two (2) weeks in advance of conducting tests. The Contractor shall have qualified personnel present during all testing.
- D. All tests shall be completely documented with the time of day, date, temperature, and all other pertinent test information. All required documentation of readings indicated shall be submitted to the Architect/Engineer prior to, and as one of the prerequisites for, final acceptance of the project.
- E. Electrical Distribution System Tests: All current carrying phase conductors and neutrals shall be tested as installed, and before load connections are made, for insulation resistance and accidental grounds. This shall be done with a 500 volt megger. The following procedures shall be as follows:
 1. Minimum readings shall be one million (1,000,000) ohms or more for #6 AWG wire and smaller; 250,000 ohms or more for #4 AWG wire or larger.

- Measurement to be taken between conductors and between conductor and the grounded metal raceway
2. After all fixtures, devices and equipment are installed and all connections completed to each panel, the Contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and grounded enclosure. If this reading is less than 250,000 ohms, the Contractor shall disconnect the branch circuit neutral wires from this neutral bar. The Contractor shall then test each one separately to the panel until the low reading ones are found. The Contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.
 3. The Contractor shall send a letter to the Architect/Engineer, and to the North Carolina State Construction Office certifying that the above has been done and tabulating the megger readings for each panel. This shall be done at least four (4) days prior to final inspection.
 4. At inspection, the Contractor shall furnish a megger and show Architect/Engineer's representative that the panels comply with the above requirements. The Contractor shall also furnish a clamp type ammeter and a voltmeter and take current and voltage readings as directed by the representatives.
 5. At inspection, the Contractor shall furnish ladders, required tools, and mechanics to open fixtures, boxes, panels, or any other equipment to enable the Architect/Engineer's representatives to see into any parts of the installation that may be requested.
- F. Electrical Grounding System Tests: Provide documentation showing values of earth ground impedance for the system ground. See Specifications Section 260526 for testing requirements.
- G. Ground Fault Protection System: Ground fault protection shall be performance tested in the field and properly calibrated and set in accordance with the coordination study. In the absence of a coordination study, set all adjustments to minimum, unless directed otherwise by the Architect/Engineer.

1.14 SLEEVES AND FORMS FOR OPENINGS

- A. Anchor bolts, sleeves, inserts, supports, etc., that may be required for electrical work shall be furnished, located and installed by the Electrical Contractor. The Electrical Contractor shall give sufficient information (marked and located) to the General Contractor in time for proper placement in the construction schedule. Should the Electrical Contractor delay or fail to provide sufficient information in time, then the Electrical Contractor shall cut and patch construction as necessary and required to install electrical work. Such cutting and patching will be done by the General Contractor but paid for by the Electrical Contractor.
- B. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.
- C. Where exact locations are required by equipment for stubbing-up and terminating conduit concealed in floor slabs, request shop drawings, equipment location drawings, foundation

drawings, and any other data required to locate the concealed conduit before the floor slab is poured.

- D. Where such data is not available in time to avoid delay in scheduled floor slab pours, the Architect/Engineer may elect to allow the installations of such conduits to be exposed. No additional compensation for such change will be allowed and written approval must be obtained from the Architect/Engineer.
- E. Seal all openings, sleeves, penetration, and slots as specified and as shown on the Contract Drawings.

1.15 CUTTING AND PATCHING

- A. For the purposes of the Electrical Contract, "cutting and patching" shall be defined as that work required to introduce new electrical work into existing construction. Work required to install or fit electrical boxes, conduit, enclosures, equipment, etc. into new construction is not "cutting and patching".
- B. The Electrical Contractor shall perform all cutting and patching necessary to install all equipment as required under his contract and shall re-establish all finishes to their original condition where cutting and patching occur.
- C. All cutting and patching shall be done in a thoroughly workmanlike manner.
- D. Core drill holes in existing concrete floors and walls as required.
- E. Install work at such time as to require the minimum amount of cutting and patching.
- F. Do not cut joists, beams, girders, columns or any other structural members without first obtaining written permission from the Architect/Engineer.
- G. Cut opening only large enough to allow easy installation of the conduit.
- H. Patching is to be of the same kind of material as was removed.
- I. The completed patching work shall restore the surface to its original appearance.
- J. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.
- K. Remove rubble and excess patching materials from the premises.
- L. Raceways and ducts penetrating rated floor, ceiling or wall assemblies shall be properly sealed in accordance with the corresponding Underwriters Laboratories approved method utilizing approved and listed materials.

1.16 INTERPRETATION OF DRAWINGS

- A. The Electrical drawings and specifications are complementary each to the other and what may be called for by one shall be as binding as if called for by both. The drawings are

diagrammatic and indicate generally the location of outlets, devices, equipment, wiring, etc. Drawings shall be followed as closely as possible; however, all work shall suit the finished surroundings and/or trim.

- B. Do not scale electrical drawings. Refer to the architectural drawings for dimensions.
- C. Where the words “furnish and install” or “provide” are used, it is intended that this contractor shall purchase and install completely any and/or all material necessary and required for this particular item, system, equipment, etc.
- D. Where the words “the Contractor” or “this Contractor” appear in either the Electrical Drawings or Division 26 Specifications, it shall mean the Electrical Contractor.
- E. Any omission from either the drawings or these specifications are unintentional, and it shall be the responsibility of this Contractor to call to the attention of the Architect/Engineer any pertinent omissions before submitting a bid. Complete and working systems are required, whether every small item of material is shown and specified or not.
- F. Where no specific material or equipment type is mentioned, a high quality product of a reputable manufacturer may be used provided it conforms to the requirements of these specifications. These materials shall be listed or labeled by a Third Party Testing Agency accredited by the NCBC to label electrical equipment.
- G. The electrical drawings show the general arrangement of raceways, equipment, fixtures, and appurtenances and shall be followed as closely as actual building construction and the work of other trades will permit. Some adjustment of routings and installation of conduit, cable tray and devices should be expected. The electrical work shall conform to the requirements shown on all of the drawings. General and Structural drawings shall take precedence over Electrical Drawings. Because of small scale of the electrical drawings, it is not possible to indicate offsets, fittings and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings and accessories as may be required to meet such conditions, without additional cost to the Owner and as directed by the Architect/Engineer.
- H. Each 3-phase circuit shall be run in a separate conduit unless otherwise shown on the Drawings.
- I. Unless otherwise approved by the Architect/Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- J. Where circuits are shown as “home runs” all necessary fittings and boxes shall be provided for a complete raceway installation.
- K. Verify with the Architect/Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- L. Any work installed contrary to or without approval by the Architect/Engineer shall be subject to change as directed by the Architect/Engineer, and no extra compensation will be allowed for making these changes.

- M. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Architect/Engineer during construction. Obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Architect/Engineer and furnish all labor and materials necessary to complete the work in an approved manner.
- N. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- O. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of equipment.
- P. All connections to the equipment shall be made as required, and in accordance with the approved shop and setting drawings.
- Q. Redesign of electrical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at the Contractor's expense. Redesign and detailed plans shall be submitted to the Architect/Engineer for approval. No additional compensation will be provided for changes in the work, either the Electrical Contractor's or others, caused by such redesign.
- R. All floor mounted electrical equipment shall be placed on 4-inch thick concrete housekeeping pads. Edges shall be chamfered.

1.17 RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on one set of project contract drawings, herein after called the "record drawings".
- B. Record drawings shall accurately show the installed condition of the following items:
 - 1. Power distribution one-line diagram(s).
 - 2. Panel schedule(s).
 - 3. Lighting fixture schedule(s).
 - 4. Feeder, branch circuit conduit and conductor sizes.
 - 5. Lighting fixture, receptacle, and switch outlets, interconnections and homeruns with circuit identification.
 - 6. Plan view, sizes and locations of panelboards.
 - 7. Fire alarm system.

1.18 CORROSION PROTECTION

All equipment, raceways, hardware, etc., furnished under the electrical contract shall be protected from corrosion by factory applied coatings, paint and galvanizing, or shall be fabricated of high quality 300 series stainless steel. All exposed hardware shall be hot dip galvanized. The requirements of preceding section entitled "Delivery and Storage" shall be strictly followed.

Touch up any scratched metallic surfaces immediately to prevent corrosion. Apply cold galvanizing compound to all galvanized surfaces damaged during installation, i.e., cutting, etc. Rusted or corroded materials shall be replaced before final acceptance of the work.

1.19 SEISMIC REQUIREMENTS

- A. All equipment furnished under the electrical contract shall be installed in a manner to be fully compliant with the seismic restraint requirements of the North Carolina State Building Code (NCSBC). The Contractor shall provide any and all seismic restraint details and calculations that may be required by the NCSBC and/or the Authority Having Jurisdiction.
- B. Requirements for restraints are detailed in the NCSBC. All tables and references shall conform to building's location. Restraints shall be per Seismic Performance Category stated on Architectural Drawings.
- C. The Contractor shall retain the services of a Professional Engineer registered in the State of North Carolina to design seismic restraint elements required for this project. The Engineer's calculations, bearing his professional seal, shall accompany shop drawings and shall demonstrate Code compliance including certification that the seismic system components comply with the testing requirements of NCSBC Section 1708.5. Calculations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment, systems and assemblies. Internal seismic restraint elements of manufactured equipment shall be certified by a professional engineer retained by the manufacturer. Such certificate applies only to internal elements of the equipment. All equipment anchorage requirements shall be coordinated with the building structure and shall be compatible thereto. All such anchorages shall be subject to the review and approval of the project's structural engineer.
- D. The Professional Engineer retained for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation to comply with the Special Inspections requirement of the Code. This engineer shall provide written verification of compliance of the installation with the approved seismic submittal. This verification shall be submitted as a Special Inspections Report and shall bear the Engineer's professional seal. Job site inspections by other than this engineer are not acceptable.
- E. Review of the seismic design computations and shop drawings by the Architect/Engineer or his agent shall not relieve the Contractor of his responsibility to comply with the seismic or any other requirements of the North Carolina State Building Code.

1.20 GUARANTEE

The Contractor shall guarantee the materials and workmanship covered by these drawings and specifications for a period of one year from the date of acceptance by the Owner. The Contractor shall repair and/or replace any parts of any system that may prove to be defective at no additional cost to the Owner within the guarantee period. All equipment warranties shall be as specified and included in the Contract Documents.

1.21 PHASING OF THE WORK

The Electrical Contractor shall schedule his work as described in the relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

1.22 ALTERNATE BIDS

Alternate bid items are described in relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

PART 2 PRODUCTS Not used.

PART 3 EXECUTION Not used.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.2 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- 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. Alcan Products Corporation: Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.
- C. Copper Conductors: Comply with NEMA WC 70.
- D. Conductor Insulation: Comply with NEMA WC 70 for Types THW and THHN-THWN.
- E. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC and metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway
- B. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- C. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway
- D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway, Armored cable, Type AC, Metal-clad cable, Type MC.
- E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- G. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- H. Class 2 Control Circuits: Type THHN-THWN, in raceway or Power-limited cable, concealed in building finishes.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

- c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

- D. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

- E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Instructions for periodic testing and inspection of grounding features at based on NETA MTS.
 - a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- 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.
- C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection,

with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow

- C. **Grounding Bus:** Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.
- D. **Conductor Terminations and Connections:**
 - 1. **Pipe and Equipment Grounding Conductor Terminations:** Bolted connectors.
 - 2. **Underground Connections:** Welded connectors except at test wells and as otherwise indicated.
 - 3. **Connections to Ground Rods at Test Wells:** Bolted connectors.
 - 4. **Connections to Structural Steel:** Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. **Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:**
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored and metal-clad cable runs.
- B. **Water Heater Cables:** Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- C. **Isolated Grounding Receptacle Circuits:** Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

3.3 INSTALLATION

- A. **Grounding Conductors:** Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. **Bonding Straps and Jumpers:** Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

C. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 LABELING

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for instruction signs. The label or its text shall be green.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.

1.2 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.3 QUALITY ASSURANCE

- A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc., Masterset Fastening Systems Unit.
2. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
3. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
4. Toggle Bolts: All-steel springhead type.
5. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 6. To Light Steel: Sheet metal screws.
 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Metal conduits, tubing, and fittings.
 2. Surface raceways.
 3. Boxes, enclosures, and cabinets.

1.2 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.3 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. Anamet Electrical, Inc.
 4. Electri-Flex Company
 5. O-Z/Gedney; a brand of EGS Electrical Group.
 6. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
 7. Republic Conduit.
 8. Robroy Industries.
 9. Southwire Company.
 10. Thomas & Betts Corporation.
 11. Western Tube and Conduit Corporation.
 12. Wheatland Tube Company; a division of John Maneely Company

- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. EMT Comply with ANSI C80.3 and UL 797.
- E. FMC: Comply with UL 1; zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- H. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mono-Systems, Inc.
 - b. Panduit Corp.
 - c. Wiremold / Legrand.
- C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems Division.
 - b. Mono-Systems, Inc.
 - c. Panduit Corp.
 - d. Wiremold Legrand.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Adalet.
 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 3. EGS/Appleton Electric.
 4. Erickson Electrical Equipment Company.
 5. FSR Inc.
 6. Hoffman; a Pentair company.
 7. Hubbell Incorporated; Killark Division.
 8. Kraloy.
 9. Milbank Manufacturing Co.
 10. Mono-Systems, Inc.
 11. O-Z/Gedney; a brand of EGS Electrical Group.
 12. RACO; a Hubbell Company.
 13. Robroy Industries.
 14. Spring City Electrical Manufacturing Company.
 15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
 16. Thomas & Betts Corporation.
 17. Wiremold / Legrand.
- B. **General Requirements for Boxes, Enclosures, and Cabinets:** Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. **Sheet Metal Outlet and Device Boxes:** Comply with NEMA OS 1 and UL 514A.
- D. **Nonmetallic Outlet and Device Boxes:** Comply with NEMA OS 2 and UL 514C.
- E. **Luminaire Outlet Boxes:** Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- F. **Small Sheet Metal Pull and Junction Boxes:** NEMA OS 1.
- G. **Box extensions used to accommodate new building finishes** shall be of same material as recessed box.
- H. **Device Box Dimensions:** 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep).

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: RNC, Type EPC-80-PVC.
 2. Concealed Conduit, Aboveground: RNC, Type EPC-40-PVC.
 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT
 2. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
 - a. Mechanical rooms.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 5. Damp or Wet Locations: GRC.
 6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 1/2-inch (16-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use compression, fittings. Comply with NEMA FB 2.10.
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C)]

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- K. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly
- L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- N. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- Q. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end

of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

R. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

W. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to bottom of box unless otherwise indicated.

X. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

Z. Locate boxes so that cover or plate will not span different building finishes.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Warning labels and signs.
3. Instruction signs.
4. Equipment identification labels.
5. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- ##### A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- ##### A. Comply with ANSI A13.1.
- ##### B. Comply with NFPA 70.
- ##### C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

- ##### A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- ##### B. Coordinate installation of identifying devices with location of access panels and doors.
- ##### C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- ##### A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- ##### B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.
- E. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
1. Black letters on an orange field.
 2. Legend: Indicate voltage.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
- D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Baked-Enamel Warning Signs:
1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 3. Nominal size, 7 by 10 inches (180 by 250 mm).

C. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.4 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

3.2 IDENTIFICATION SCHEDULE

- A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- C. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- D. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- E. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 2. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.

END OF SECTION 260553

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

- A. SVR. Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 3. Include evidence of NRTL listing for series rating of installed devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency
- B. Field Quality-Control Reports:
 - 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.
- C. Panelboard Schedules: For installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Two spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.9 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

1.10 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

- B. Enclosures: Flush -mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door with hinged trim cover.
 - 4. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 - 5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Bottom.
- D. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical type.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. **Panelboards:** NEMA PB 1, lighting and appliance branch-circuit type.
- C. **Mains:** Circuit breaker.
- D. **Branch Overcurrent Protective Devices:** Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. **Doors:** Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. **Molded-Case Circuit Breaker (MCCB):** Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. **Thermal-Magnetic Circuit Breakers:** Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. **GFCI Circuit Breakers:** Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 3. **Ground-Fault Equipment Protection (GFEP) Circuit Breakers:** Class B ground-fault protection (30-mA trip).
 - 4. **Molded-Case Circuit-Breaker (MCCB) Features and Accessories:**
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads.
 - d. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.

2.4 PANELBOARD SUPPRESSORS

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
1. Current Technology; a subsidiary of Danahar Corporation.
 2. Eaton Electrical Inc., Cutler-Hammer Business Unit.
 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 4. Liebert Corporation.
 5. Siemens Energy & Automation, Inc.
 6. Square D; a brand of Schneider Electric.
- B. **Surge Protection Device:** IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
1. **Accessories:**
 - a. LED indicator lights for power and protection status.
 - b. Audible alarm, with silencing switch, to indicate when protection has failed.
 - c. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- D. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
- E. Install filler plates in unused spaces.
- F. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- H. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. **Manufacturer's Field Service:** Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. **Perform tests and inspections.**
 1. **Manufacturer's Field Service:** Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. **Acceptance Testing Preparation:**
 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- D. **Tests and Inspections:**
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. **Initial Infrared Scanning:** After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. **Follow-up Infrared Scanning:** Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. **Instruments and Equipment:**

- 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Weather-resistant receptacles.
4. Snap switches and wall-box dimmers.

1.2 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. **Operation and Maintenance Data:** For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Manufacturers' Names:** Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. **Source Limitations:** Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Comply with NFPA 70.

2.3 STRAIGHT-BLADE RECEPTACLES

- A. **Convenience Receptacles, 125 V, 20 A:** Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
 - 1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), CR5362 (duplex).
 - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

- A. **General Description:**
 - 1. Straight blade, non-feed-through type.
 - 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
 - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
- B. **Duplex GFCI Convenience Receptacles, 125 V, 20 A.**

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; VGF20.
 - b. Hubbell; GFR5352L.
 - c. Pass & Seymour; 2095
 - d. Leviton; 7590.

2.5 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Cooper; CWL520R.
- b. Hubbell; HBL2310.
- c. Leviton; 2310.
- d. Pass & Seymour; L520-R.

2. Description:

- a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
- b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B. Switches, 120/277 V, 20 A.

1. Products: Subject to compliance with requirements, provide one of the following:

- 1) Single Pole:
 - 2) Cooper; AH1221.
 - 3) Hubbell; HBL1221
 - 4) Leviton; 1221-2.
 - 5) Pass & Seymour; CSB20AC1.
- 6) Two Pole:
 - 7) Cooper; AH1222.
 - 8) Hubbell; HBL1222.
 - 9) Leviton; 1222-2.
 - 10) Pass & Seymour; CSB20AC2.

- 11) Three Way:
- 12) Cooper; AH1223
- 13) Hubbell; HBL1223
- 14) Leviton; 1223-2.
- 15) Pass & Seymour; CSB20AC3.

- 16) Four Way:
- 17) Cooper; AH1224.
- 18) Hubbell; HBL1224.
- 19) Leviton; 1224-2.
- 20) Pass & Seymour; CSB20AC4.

2.7 WALL-BOX DIMMERS

- A. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 1. 600 W; dimmers shall require no derating when ganged with other devices.

2.8 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
 1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. Material: Smooth, high-impact thermoplastic.
 3. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, thermoplastic with lockable cover.

2.9 FINISHES

- A. Device Color:
 1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
- B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Device Installation:
 - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
 - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - 8. Tighten unused terminal screws on the device.
 - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Dimmers:
1. Install dimmers within terms of their listing.
 2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- 3.2 GFCI RECEPTACLES
- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.
- 3.3 IDENTIFICATION
- A. Comply with Section 260553 "Identification for Electrical Systems."
- 3.4 FIELD QUALITY CONTROL
- A. Perform the following tests and inspections:
1. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V
 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Interior lighting fixtures, lamps, and ballasts.
 2. Emergency lighting units.
 3. Exit signs.

1.2 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT. Correlated color temperature.
- C. CRI: Color-rendering index.
- D. LER. Luminaire efficacy rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
 2. Emergency lighting units including battery and charger.
 3. Ballast, including BF.
 4. Energy-efficiency data.
 5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
- B. Installation instructions.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- B. Field quality-control reports.

- C. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

- 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Lamps: 10 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: One of each type and rating installed. Furnish at least one of each type.
 - 3. Ballasts: One of each type and rating installed. Furnish at least one of each type.
 - 4. Globes and Guards: One of each type and rating installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

- A. 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.

- B. Comply with NFPA 70.

1.8 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.9 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

2. Warranty Period for Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. Metal Parts: Free of burrs and sharp corners and edges.
- E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- G. Diffusers and Globes:
 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
 - b. UV stabilized.
 2. Glass: Annealed crystal glass unless otherwise indicated.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 1. Label shall include the following lamp and ballast characteristics:

- a. "USE ONLY" and include specific lamp type.
- b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
- c. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
- d. CCT and CRI for all luminaires.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.
3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
4. Sound Rating: Class A.
5. Total Harmonic Distortion Rating: Less than 10 percent.
6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
7. Operating Frequency: 42 kHz or higher.
8. Lamp Current Crest Factor: 1.7 or less.
9. BF: 0.88 or higher.
10. Power Factor: 0.95 or higher.
11. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

B. Electronic Programmed-Start Ballasts for T8 Lamps: Comply with ANSI C82.11 and the following:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.

C. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

D. Ballasts for Exterior Lighting Fixtures:

1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

- ### A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: Class A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher unless otherwise indicated.
9. Power Factor: 0.95 or higher.
10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

2.5 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay
 - c. Operation: 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.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 1. Battery: Sealed, maintenance-free, lead-acid type.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay
 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.7 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2950 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours unless otherwise indicated.
- B. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours unless otherwise indicated.
- C. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, unless otherwise indicated.
 1. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures:
 1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 2. Install lamps in each luminaire.
- B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- C. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
 1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

END OF SECTION 265100