Spanish Fork Santaquin Pipeline
Santaquin Reach

VOLUME 2

DIVISION 02 through DIVISION 30

CENTRAL UTAH WATER
CONSERVANCY DISTRICT

(801) 226-7100
October 2023

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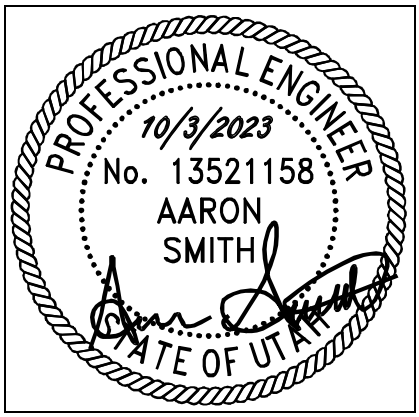

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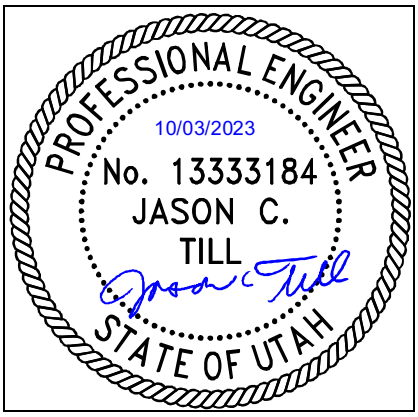

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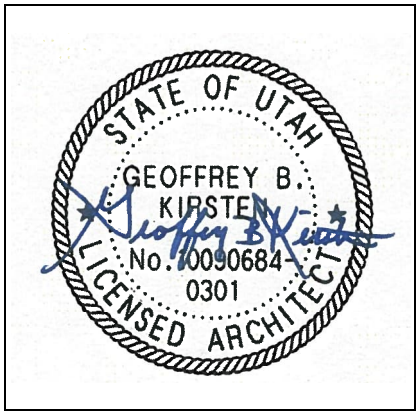

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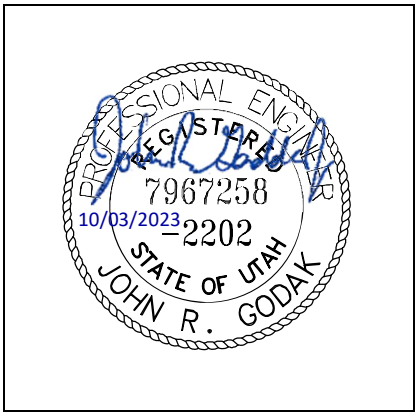

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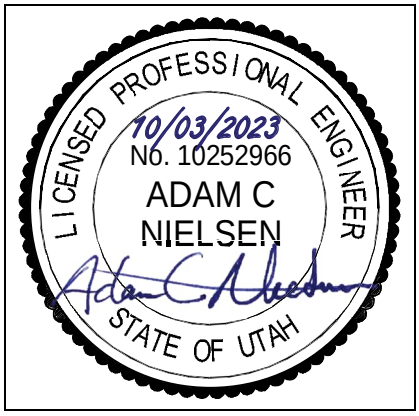

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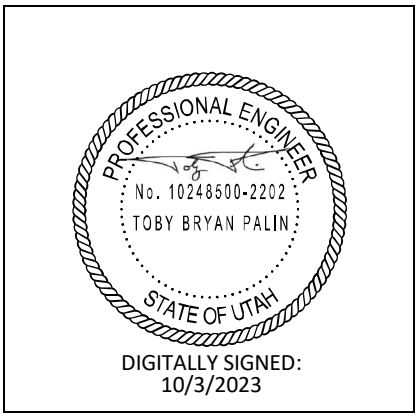

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SECTION 02 33 00
TUNNELED CROSSINGS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes requirements for tunneled crossings. Base Bids and select equipment based on the soil and groundwater conditions baselined in this section. In no case will any geotechnical reports take precedence over soil and groundwater conditions baselined for the tunneled crossings and associated shafts and risers (as applicable) in this section.

1.02 SUBMITTALS

A. Informational Submittal:

1. Abandonment Contingency Plan: Prepare an Abandonment Contingency Plan for each crossing to handle the possibility that a tunneled crossing cannot be completed. Submit the Abandonment Contingency Plan in writing to the Engineer 2 weeks prior to commencement of tunnel operations. Follow and manage provisions of the approved Plan.

1.03 DEFINITIONS

A. Casing: As defined in Section 33 05 01.27, Steel Casing Pipe.

B. Auger Boring: As defined in Section 31 79 25, Guided Auger Boring.

C. Open Face Rotary Wheel TBM Tunneling, as defined in Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.

D. Radial Overcut: Radial overcut is defined as the difference between the maximum diameter created by the cutting teeth, cutting shoe, or overcut band on the machine or auger (whichever is greater) and the outer diameter of the casing, divided by two.

E. Riser Pipe: Segment of the pipeline that transitions from a trenchless crossing to a more shallow open cut portion of the pipeline.

1.04 DESIGN CRITERIA

A. Employ methods and equipment that will control surface settlement and heave above the tunnel to prevent damage to existing utilities, facilities, and improvements. Limit ground movements (settlement/heave) to values that do not cause damage or distress to surface features, utilities, or

improvements. In no case will settlements exceed the shutdown values provided in Section 31 80 00, Geotechnical Instrumentation. Repair damage to existing features, improvements, or utilities to the satisfaction of the Engineer, the Owner, and the owner of the affected features, improvements, or utilities.

B. The allowable construction methods for each crossing are:

1. 60-inch encased crossing of Interstate 15: Auger Boring to install steel casing in accordance with Section 31 79 25, Guided Auger Boring or Open Face Rotary Wheel TBM Tunneling to install steel casing or steel liner plate in accordance with Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.
2. 60-inch encased crossing of US Highway 6: Auger Boring to install steel casing in accordance with Section 31 79 25, Guided Auger Boring or Open Face Rotary Wheel TBM Tunneling to install steel casing or steel liner plate in accordance with Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.
3. 60-inch encased crossing of UPRR tracks: Auger Boring to install steel casing in accordance with Section 31 79 25, Guided Auger Boring or Open Face Rotary Wheel TBM Tunneling to install steel casing in accordance with Section 31 79 19, Open Face Rotary Wheel TBM Tunneling.

C. Do not propose or utilize any other method without written permission from the Engineer. Demonstrate that the proposed alternate method is technically feasible and will result in settlement less than the shutdown values presented in Section 31 80 00, Geotechnical Instrumentation. Submit three examples of crossings of similar lengths and in similar soil conditions where the proposed alternate was successfully completed.

D. The maximum radial overcut is 3/4 inch. The maximum allowable radial overcut value has been selected to minimize potential settlements of the ground and subsurface facilities.

1.05 PERMITS

A. The Owner has obtained permits to cross the Interstate, Highway, and UPRR tracks. Comply with all requirements of these permits. Refer to Section 01 51 00, Permits and Regulatory Requirements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Subsurface conditions anticipated to be encountered during construction of the crossings are presented in the attached Geotechnical Baseline Report (GBR). The GBR defines the conditions on which the Contractor shall base all Bids and develop schedules.

3.02 GEOTECHNICAL CONDITIONS

A. The primary purpose of the baseline subsurface conditions presented in the GBR is to establish a contractual understanding of the geotechnical conditions anticipated to be encountered during construction of the tunneled portions of the Project in order to provide a basis for bidding and to assist in resolution of disputes that may arise over subsurface conditions during tunneling. Secondarily, the definitions:

1. Present the geotechnical and construction conditions that formed the basis of tunnel design.
2. Provide information to assist the Contractor in evaluating requirements for excavating and supporting the ground.
3. Provide guidance to the Engineer in administering the Contract.

B. The results of the Project geotechnical investigations are contained in the Geotechnical Data Report (GDR) as identified in SC.5.03. If there are disagreements or ambiguities between the baseline conditions presented in the GBR and the Technical Data contained in the GDR, the GBR takes precedence.

C. It is recommended that Bidders have a geotechnical engineer or engineering geologist licensed in the State of Utah review and explain the information to assure a complete understanding of the reported information as a basis for submitting a Bid.

3.03 RISK ALLOCATION

A. Risks associated with subsurface conditions consistent with, or less adverse than, the conditions defined in the GBR are allocated to the Contractor. The risk of higher construction costs associated with subsurface conditions more adverse than the conditions presented herein are accepted by the Owner. The baseline of the subsurface conditions in the Contract is not a warranty that the baselined conditions will be encountered. The baselined conditions are the contractual standard that the Owner and the Contractor will agree to use when interpreting the

differing subsurface or physical conditions clause, contained in Paragraph 5.04 of the General Conditions.

B. In the event that Contractor believes more adverse conditions have been encountered, the Owner will negotiate with the Contractor for additional compensation to the Contractor if the Owner determines the following four conditions exist:

1. Promptly notify the Owner of the differing conditions in writing in accordance with Paragraph 5.04 of the General Conditions.
2. Demonstrate that the actual subsurface conditions encountered are materially more adverse than the baselined conditions.
3. Provide documentation that the subsurface conditions are more adverse than those baselined and that the conditions materially and significantly increased the cost and/or time required to complete the Work.
4. Diligent efforts were made to complete the Work described in the Contract Documents, including any changes to methods, equipment, labor, and materials made necessary by the more adverse conditions.

C. If the foregoing conditions are satisfactorily met, additional compensation will be negotiated in accordance with the requirements of Article 12 of the General Conditions.

3.04 OBSTRUCTIONS

A. If the tunneling operations should encounter an object or condition that impedes the forward progress of the machine, the Contractor shall notify the Engineer immediately.

B. The Contractor shall submit a plan to correct the condition, and remove, clear, or otherwise make it possible for the tunneling machine and casing pipe to advance past any and all objects or obstructions that impede forward progress of the casing.

C. Upon written notification of the Engineer, the Contractor shall immediately proceed with removal of the object or obstruction by means of an obstruction removal shaft or by other approved methods, as submitted by the Contractor. An obstruction removal shaft shall consist of a small excavation for the purpose of removing the obstruction.

D. The Contractor will receive compensation for removal of obstructions, which consist of metallic debris, reinforced concrete, whole trees, rocks and other hard objects larger than 33 percent of the outer diameter of the shield, cutter head, or cutting shoe, which cannot be broken up by the cutting tools with diligent effort, and that are partially or wholly within the cross-sectional area of the bore.

E. Payment will be negotiated with the Contractor by the Owner on a case-by-case basis. However, any removal process that does not allow direct inspection of the nature and position of the obstruction will not be considered for payment.

F. The Contractor will receive no additional compensation for removing, clearing, or otherwise making it possible to advance past objects consisting of cobbles, boulders, wood, nonreinforced concrete, and other nonmetallic objects or debris with maximum lateral dimensions less than 33 percent of the outer diameter of the shield, cutterhead, casing, or cutting shoe, whichever is larger.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is part of this specification.

1. Attachment: Geotechnical Baseline Report.

END OF SECTION

Geotechnical Baseline Report

Spanish Fork to Santaquin Pipeline (Santaquin Reach) Trenchless Crossings

Prepared for

Central Utah Water Conservancy District

May 2023

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Acronyms and Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
District	Central Utah Water Conservancy District
GBR	Geotechnical Baseline Report
GDR	Geotechnical Data Report
I-15	Interstate 15
psf	pounds per square foot
RB&G	RB&G Engineering, Inc.
ROW	right-of-way
SPT	standard penetration test
s_u	undrained shear strength
TBM	tunnel boring machine
UDOT	Utah Department of Transportation
ULS	Utah Lake Drainage Basin Water Delivery System
UPRR	Union Pacific Railroad
US-6	U.S. Highway 6

SECTION 1

1.Introduction

The Central Utah Water Conservancy District (District) is developing the Central Utah Spanish Fork to Santaquin Pipeline Project, Santaquin Reach in Santaquin, Utah County, Utah.

The Spanish Fork to Santaquin Pipeline is a critical water delivery and transmission facility of the Utah Lake Drainage Basin Water Delivery System (ULS), which is part of the Bonneville Unit of the Central Utah Project in central and northeastern Utah. The Central Utah Project was authorized for construction as a participating project under the Colorado River Storage Project of 1956. The Central Utah Project Completion Act passed by congress in 1992 authorized the District to plan, design, construct, and operate the remaining features of the Bonneville Unit under the oversight of the U.S. Department of Interior.

The ULS conveys a portion of the State of Utah's Colorado River Entitlement from Strawberry Reservoir within the Colorado River Drainage Basin to municipal water users along the Wasatch Front and south into Utah County. The Santaquin Reach, the last major reach of the ULS program, consists of approximately 4 miles of 60-inch-diameter welded steel pipe, extending from South State Street in the city of Spring Lake to Summit Creek Pond in the city of Santaquin.

The construction of the Santaquin Reach includes trenchless crossings of Interstate 15 (I-15), U.S. Highway 6 (US-6), and Union Pacific Railroad (UPRR) tracks. The planned trenchless crossings, including the associated launching and receiving pits / shafts (shafts) are the subject of this geotechnical baseline report (GBR).

1.1 Purpose and Use of the Geotechnical Baseline Report

1.1.1 Purpose

This GBR establishes a contractual understanding of the geotechnical conditions anticipated to be encountered during construction of the three tunneled crossings and associated shafts for the Santaquin Reach of the conveyance pipeline project. The principal purpose of the GBR is to set baselines for geotechnical conditions and material behavior anticipated to be encountered during tunnel and access shaft construction for the interstate, highway, and railroad crossings to provide a basis for bidding and to assist in resolution of disputes that may arise over subsurface conditions. In addition, this GBR also provides the following information:

- Identifies important considerations, key project constraints, and select requirements that must be addressed by the contractor during bid preparation and construction
- Provides information to assist the contractor in evaluating requirements for excavating and ground support during construction

- Provides guidance to the construction management team in administering the contract and monitoring contractor performance

1.1.2 Use

The GBR provides the basis for identifying geotechnical and geologic conditions that qualify as changed conditions, as defined in Section 5-2 of the General Conditions, for the trenchless crossings and associated shafts of this project. The geotechnical baseline condition (baseline) contained in this GBR is not necessarily geotechnical fact. The baseline was developed using judgment to interpolate between borings and extrapolate beyond the boring logs and laboratory test data. The judgment applied in the interpolations and extrapolations reflects the views of the District and the District's design consultant in describing the baseline. Bidders will use the baseline subsurface conditions and the surface conditions that can be observed during a site visit as the basis for bids. It should be noted that the project design was based on assumed construction methods and levels of workmanship. The behavior of the geologic materials present in the surface and subsurface excavations will be influenced by the contractor's selected equipment, means, and methods.

Certain plans and figures contained in other documents in the contract facilitate an understanding of related site conditions and elements of the work. These plans and figures are referenced but are not reproduced in this report. Additional documents used to develop the GBR are listed in the references section of this report. These documents are not incorporated as contract documents and are listed for reference only.

1.2 Organization of Report

This report is organized into the following sections:

- Section 1: Introduction—Provides a general project overview and outlines the purpose of the GBR.
- Section 2: Project Description—Provides a more detailed description of the tunneled railroad crossings.
- Section 3: Sources of Information—Provides sources of project information and subsurface conditions and the geologic project setting.
- Section 4: Ground Characterization—Provides descriptions of conditions encountered during subsurface exploration for the tunneled crossings and access shafts as well as baseline conditions and key material properties to be encountered during construction.
- Section 5: Construction Considerations—Provides considerations that should be addressed during construction of the tunnel crossings and access shafts.
- Section 6: References
- Figures

1.3 Limitations

This GBR has been prepared for specific application to the two trenchless highway and one trenchless rail crossings of the Santaquin Reach of the Spanish Fork to Santaquin Pipeline Project, in accordance with generally accepted geotechnical engineering practice common to the project area. No amount of investigation and analysis can predict exact characteristics, quality, or distribution of materials or behavior of those materials during construction. Such characteristics will vary with depth and aerial extent. Behavior will depend on material characteristics and their inherent variability, as well as construction means and methods.

SECTION 2

2.Project Description

2.1 Background

Trenchless crossings are planned at three locations along the proposed pipeline: I-15, US-6, and UPRR. The average depths to casing invert for the I-15 and US-6 crossings are about 17 and 40 feet below ground surface (bgs), respectively; and the average depth to casing invert of the UPRR crossing is about 20 feet bgs. The following sections describe the crossings in more detail.

2.1.1 Interstate 15

This trenchless crossing is located just south of W 12800 S, is approximately 265 feet in length, and consists of a 60-inch-diameter welded steel pipe carrier within a 78-inch-diameter steel casing or an 84-inch-diameter four-flange liner plate. Both sides of the crossing are flanked by privately owned property; the launching shaft will be located within undeveloped property, and the receiving shaft will be located within a gravel access road adjacent to agricultural land.

The ground surface elevation at this crossing ranges from approximately elevation 4,750 feet to 4,759 feet above mean sea level (amsl), according to the U.S. Geological Survey datum, with the surface of the interstate at approximately 4,757 feet amsl. The minimum depth of soil cover to the casing crown is approximately 8 feet at the launching shaft, and depth of cover beneath the interstate pavement is approximately 14 feet. The invert of the casing at the launching shaft and receiving shaft will be between approximately 15 and 20 feet bgs.

No closure of the interstate is anticipated for construction; both the launching and receiving shafts are located entirely outside of the Utah Department of Transportation (UDOT) right-of-way (ROW).

There are no overhead utilities in the vicinity of the crossing; however, this crossing will pass under and perpendicular to multiple buried fiber optic cables and parallel to a 24-inch high-pressure gas main at an approximate center-to-center distance of 30 feet. The contractor is required to verify the location of all utilities prior to starting work.

The annular space between the 60-inch-diameter carrier pipe and the steel casing or liner plate will be backfilled with grout, in accordance with contract specifications.

2.1.2 U.S. Highway 6

This trenchless crossing is located just east of the UPRR tracks and south of Lark Road, is approximately 199 feet in length, and consists of a 60-inch carrier pipe within a 78-inch steel casing or 84-inch four-flange steel liner plate. The properties to the north and south of the crossing are privately owned; the launching shaft will be located within the UDOT ROW, and the receiving shaft will be located entirely within undeveloped private property. No closure of the highway is anticipated for construction.

The ground surface elevation at this crossing ranges from approximately elevation 4,883 feet to 4,911 feet amsl, the latter being the elevation of the paved highway surface. The minimum depth of soil cover to the casing crown is approximately 10 feet, and clearance beneath the highway is approximately 37 feet. The invert of the casing or liner plate at the launching shaft and receiving shaft will be approximately 14 feet bgs.

An existing 18-inch sanitary sewer within a 36-inch steel casing and a 10-inch RW line run parallel and to the west of the crossing at a center-to-center horizontal separation of between 26 and 43 feet and a center-to-center vertical separation of 4.5 feet. Additionally, the crossing will pass under and perpendicular to a fiber optic cable. The contractor is required to verify the location of all utilities prior to starting work. An overhead communication line is adjacent to the receiving shaft.

The annular space between the 60-inch-diameter carrier pipe and the steel casing or liner plate will be backfilled with grout, in accordance with contract specifications.

2.1.3 Union Pacific Railroad Crossing

This trenchless crossing is located between W 14000 S and W 14400 S and east of Summit Ridge Parkway. The crossing is approximately 92 feet in length and consists of a 60-inch carrier pipe within a 78-inch steel casing. The property to the east is state-owned, and the property to the west is privately owned. The launching and receiving shafts will be located outside of the railroad ROW.

The ground surface elevation at this crossing ranges from approximately elevation 4,916 feet to 4,926 feet amsl; the UPRR tracks are at elevation 4,918 feet. The minimum depth of soil cover to the casing crown is approximately 12.5 feet, and clearance beneath the tracks is approximately 15 feet. The invert of the casing at the launching shaft and receiving shaft will be between approximately 17 and 20 feet bgs.

No overhead utilities are present at this site, and an 18-inch gravity sewer pipe crosses the alignment at the launching shaft. The contractor may elect to bypass the sewer, support the sewer within the shaft, or shift the launching shaft to avoid the sewer.

The annular space between the 60-inch-diameter carrier pipe and the 78-inch-diameter steel casing will be backfilled with grout, in accordance with contract specifications.

SECTION 3

3.Sources of Information

3.1 Topographic Data

Aerial photos, topographic data, and base map information used in the preparation of the GBR were provided by the District and were based on an aerographics flight in April 2018. Ground surveying was provided by Horrocks Engineers. All elevations referenced in this report are based on the North American Vertical Datum of 1988 (NAVD 88), and coordinates are based on modified Utah State Coordinate System Central Zone, North American Datum of 1983 (NAD 83) U.S. Survey Feet.

3.2 Geologic Setting

The project site is located in the city of Santaquin within Utah County, which is south of Utah Lake, Utah. This geologic region is called Lake Bonneville and consists of three formations: the Alpine (oldest), Bonneville, and Provo (youngest). The Alpine formation is divided into gravel, sand, silt, and clay members. The Bonneville formation is much thinner and is the smallest in volume of the Lake Bonneville group. The Provo formation was deposited after Lake Bonneville had receded to the Provo shoreline. This formation is also subdivided into gravel, sand, silt, and clay members. Fan gravel of late- and post-Provo age overlies the Provo formation; the gravel was deposited as streams incised the deltas during the final recession of Lake Bonneville, in late Provo time. Other post-Provo deposits include those of Utah Lake, which are 50 feet in maximum thickness and are subdivided into gravel, sand, silt, clay, and tufa units; eolian sand; and alluvium of Utah Lake age, deposited on the youngest fans and modern stream floodplains (Bissell 1963).

The Spanish Fork area is located at the center of the Intermountain Seismic Belt portion in Utah. This zone has pronounced seismic activity that extends from northwest Montana to southwest Utah. The seismic zone follows the north-south trending Hurricane and Wasatch fault zones (Golder 2009). The Provo section of the Wasatch Fault has been mapped southeast of the project pipeline alignment, near Powerhouse Road (RB&G 2016). According to the Utah Geological Survey Utah Quaternary Fault and Fold Map, the Wasatch fault zone is one of the longest and most tectonically active normal faults in North America.

3.3 Geologic Mapping

According to the Utah Geological Survey, Interim Geologic Map of Unconsolidated Deposits in the Santaquin Quadrangle (UGS 2010), the surficial geology within the vicinity of the crossings is characterized by lacustrine and alluvial deposits of Lake Bonneville stratigraphy from the upper Pleistocene.

The I-15 crossing consists of lacustrine deposits (Qlmb) with thick beds of silt and clay with minor fine sand. This layer may be up to 15 feet thick and overlies lacustrine gravel, sand,

and silt (Qlgb and Qlsb). The UPRR crossing also lies within lacustrine deposits (Qlgb); however, this area likely contains more gravel and sand than may be seen near the I-15 crossing, is likely less than 3 feet thick, and overlies older alluvial-fan deposits. The US-6 crossing is located within alluvial fan deposits (Qafp, Qafy) and stream deposits (Qal_1). Qafp contains poorly to moderately sorted pebble to cobble gravel; locally bouldery in a matrix of sand, silt, and minor clay; and is medium to very thickly bedded (up to 30 feet). Qal_1 contains moderately sorted pebble and cobble gravel with a matrix of sand, silt, and minor clay with thin sand lenses and is thin to medium bedded (up to 15 feet). Qafy contains poorly to moderately sorted pebble to cobble gravel with a matrix of sand, silt, and clay, grading to mixtures of sand, silt, and clay, likely of thickness less than 40 feet.

3.4 Previous Geotechnical Investigations

UDOT completed a subsurface investigation for the construction of the US-6 bridge over the UPRR tracks in 2003 (UDOT 2004). This geotechnical investigation consisted of several soil borings, two of which (B-3, B-6) are in the vicinity of the US-6 crossing.

Boring 6 and boring 3 were drilled approximately 90 feet and 200 feet west of the US-6 crossing, respectively. These borings were advanced using a CME 850 truck-mounted drill rig with a hollow-stem auger and a noted hammer efficiency of 0.8. Although no laboratory report was available, test results were provided on the logs. The elevation of the borings placed them 82 feet below the crest of the US-6 embankment. It is possible that UDOT referenced a project-specific datum on the logs, which explains why the bridge deck elevation was shown as elevation 4,851 feet; and therefore the subsurface data could not be directly incorporated.

3.5 Project Geotechnical Investigation

From 2019 to 2022, RB&G Engineering, Inc. (RB&G), under subcontract to Jacobs, drilled 21 borings along the proposed pipeline alignment and installed 9 monitoring wells. All borings were completed with either a CME 55 or CME 75 rotary drill rig. Where a CME 55 drill rig was used, advancement was made with either a tri-cone rock bit or HWT casing. Where a CME 75 drill rig was used, advancement was made with a 4.5-inch hollow-stem auger. Disturbed and relatively undisturbed samples were gathered at 2.5-foot intervals in the upper 20 feet and 5-foot intervals below 20 feet. Standard penetration testing (SPT) was performed using 2.5-inch-outside-diameter split-spoon sampler a distance of 18 inches using a 140-pound weight dropped 30 inches.

Laboratory testing performed on the project-specific borings includes sieve analyses (American Society for Testing and Materials [ASTM] D6913), Atterberg limits (ASTM D4318), hydrometer (ASTM D422), unconfined compression (ASTM D2166), and electro-chemical testing.

Of the twenty-one borings completed, five were completed in the vicinity of the trenchless crossings; BH-19-10 and BH-19-11 were completed in 2019 near the I-15 crossing, BH-22-10 and BH-22-11 were completed in 2022 near the US-6 crossing, and BH-22-18 was completed in 2022 near the UPRR crossing. Boring logs and laboratory test results are provided in the Geotechnical Data Report (GDR) (RB&G 2022).

SECTION 4

4.Ground Characterization

4.1 General

4.1.1 Soil Classification

In the preparation of this GBR, soil has been classified using the Unified Soil Classification System (ASTM D2487). According to ASTM D2487, a cobble is defined as a rock that will not pass a square opening of 3 inches, no matter how it is oriented in the opening. A boulder is defined as a rock that will not pass a square opening of 12 inches during a similar test.

The consistency and relative density of the soil included in the soil description relies on the SPT blow count, obtained during the subsurface investigations, to determine the relative resistance to penetration of the soil. Whenever correlations to blow count are used, it is important that the blow counts reported in the boring logs are corrected for varied drilling and sampling methods. $N_{1(60)}$ values are provided on the boring logs, with hammer efficiency ranging from 0.82 to 0.83.

4.1.2 Consistency and Relative Compaction

The consistency (description) and undrained shear strength (s_u) for cohesive soils and relative density (description) for non-cohesive soils encountered were determined using the guidelines presented in Terzaghi et al. (1996), as summarized in Table 1.

TABLE 1
Summary of Consistency and Relative Compaction Descriptors

Soil Type	Description	Blow Count (blows per foot)	s_u (psf)
Cohesive	Very Soft	<2	<250
	Soft	2–4	250–500
	Firm	5–8	500–1,000
	Stiff	9–15	1,000–2,000
	Very Stiff	16–30	2,000–4,000
	Hard	>30	>4000
Non-cohesive	Very Loose	0–4	
	Loose	5–10	
	Medium Dense	11–30	
	Dense	31–50	
	Very Dense	>50	

Notes:

psf = pounds per square foot
s_u = undrained shear strength

4.1.3 Standup Time

Anticipated ground behavior has been evaluated for standup time and face stability using the Tunnelman's Ground Classification (Heuer 1974). This provides an indication of the ground behavior that can be expected if the tunnel face is left unsupported during excavation. The estimated behavior is often used to assist in selecting suitable excavation, tunneling, and ground support methods. The Tunnelman's Ground Classification can be applied to both cohesive and cohesionless soils, both above and below the water table. General ground behavior descriptions are defined in Table 2.

TABLE 2
General Ground Behavior and Tunnelman's Ground Classification

Classification	General Ground Behavior When Exposed in Tunnel
Firm	Heading can be advanced without initial support.
Raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed. "Fast raveling" begins within a few minutes; otherwise, the ground is "slow raveling."
Cohesive Running	Material with sufficient cohesion to stand for a brief period of raveling before it breaks down and runs.
Running	Granular materials without cohesion are unstable at a slope greater than the angle of repose (+/- 30° to 35°). When exposed at steeper slopes, they run like granulated sugar or dune sand until the slope flattens to the angle of repose.
Cohesive Flowing	Material with sufficient cohesion to stand for a brief period of raveling before it breaks down and flows as a mixture of soil and water.
Flowing	A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from

TABLE 2
General Ground Behavior and Tunnelman's Ground Classification

Classification	General Ground Behavior When Exposed in Tunnel
	the invert as well as from the face, crown, and walls, and can flow for great distances as it accumulates in the tunnel.

Source: Modified after Heuer 1974.

4.1.4 Gravel and Cobble Deposits

Gravel layers containing cobbles were encountered during the geotechnical investigation in the depth range of the tunnel zone at the I-15 and US-6 crossings. A gravel deposit was encountered at an approximate elevation of 4,740 feet at the I-15 crossing and at 4,872 feet at the US-6 crossing. The deposit at the I-15 crossing is composed of Poorly Graded Gravel with Sand (GP) and Poorly Graded Gravel with Silt and Sand (GP-GM), and the deposit at the US-6 crossing is composed of Poorly Graded Gravel with Silt and Sand (GP-GM). At each of these locations, the driller noted the possibility of cobbles on the boring logs.

4.2 Interstate 15

Near the I-15 crossing, both project-specific borings were completed approximately 4 feet south of the centerline of the crossing, with one boring on each side of the interstate. BH-19-10 was drilled approximately 35 feet west of the receiving shaft; BH-19-11 was drilled approximately 40 feet east of the launching shaft. Both borings were completed to a depth of approximately 41.5 feet using a CME 55 drill rig. Casing was installed to a depth of 25 and 40 feet within BH-19-10 and BH-19-11, respectively.

4.2.1 Subsurface Conditions Encountered

Boring BH-19-10 encountered 8 feet of native lean clay (CL) and lean clay with sand (CL). Beneath this layer was a thin (1.5-foot-thick) layer of silty sand (SM) and followed by an additional thin layer of lean clay (CL). These layers are underlain by 5 feet of silty sand (SM). This boring then encountered a 2-foot-thick layer of gravel with sand (GP), within which the driller noted possible cobbles. A 5-foot-thick layer of silty sand (SM) with trace gravels (SM) followed and was underlain by 5 feet of lean clay (CL), which underlies the receiving shaft. The underlying layers include 5 feet of silty sand (SM) followed by 9 feet of lean clay with sand lenses (CL). The boring was terminated at 41.5 feet bgs within a layer of silty sand with gravel (SM).

Boring DH-19-11 encountered a 4-foot-thick layer of silty sand with gravel (SM) at the surface. Below this, an approximate 11-foot-thick layer of lean clay (CL) and lean clay with sand (CL) was encountered. Below this layer, a 4-foot-thick layer of silty sand (SM) was encountered, followed by a 7-foot-thick layer of gravel with silt and sand (GP-GM) within which the driller noted possible cobbles. This layer is followed by a thin (<1-foot-thick) layer of lean clay (CL) and a 2-foot-thick layer of silt with sand (ML). Below the ML layer, a 10-foot-thick layer of silty sand (SM) was encountered. The boring terminated approximately 4 feet below, for a total depth of 41.5 feet bgs, within a lean clay (CL).

Groundwater was encountered between 26 feet bgs (elevation 4,730 feet) at the time of drilling DH-19-11 and 33 feet bgs (elevation 4,721.5 feet) at the time of drilling DH-19-10.

4.2.2 Baseline Subsurface Conditions

The baseline subsurface soil and groundwater conditions for the I-15 crossing are described below and are illustrated on Figure 1. The transitions between materials shown on Figure 1 are approximate, and in the event of a discrepancy between the information presented in Table 3, Figure 1, and the borings logs and other descriptions contained in the GDR, Table 3 shall take precedence.

TABLE 3
Geotechnical Baseline Conditions for the Interstate 15 Crossing

Layer	Description
Fill	A surficial dense Silty Sand layer was encountered in boring DH-19-11 and is interpreted to be fill material for the adjacent interstate. This layer will not be encountered at the launching shaft but will be encountered in the upper 3 feet at the receiving shaft. This material will behave as cohesive running to fast-raveling ground.
Clay with Sand	The Clay with Sand layer extends from the surface to 11 feet bgs at the launching shaft and from 3 to 14 feet bgs at the receiving shaft. The layer will be present above the springline of the tunnel at the launching shaft, tapering out of the face completely by the receiving shaft. This layer is composed of stiff to very stiff lean clay (CL) grading to lean clay with sand (CL) with occasional lenses of silty sand (SM), all with corrected blow counts ranging from 5 to 53 with an average of 29 blows per foot. The plasticity index ranges from 10 to 30. The clay contains less than 15 percent sand, and the lenses of silty sand contain greater than 20 percent silt. The clay has an average s_u of 2,500 psf. The clay material will behave as slow-raveling to firm ground. The silty sand lenses will be less than 12 inches in height and will behave as fast- to slow-raveling ground.

TABLE 3
Geotechnical Baseline Conditions for the Interstate 15 Crossing

Upper Silty Sand	The Upper Silty Sand layer extends from 11 to 15 feet bgs at the launching shaft and from 14 to 19 feet bgs at the receiving shaft. This layer will be present below the springline at the launching shaft, transitioning to almost a full face at the midpoint of the crossing, and ultimately to the upper two thirds of the crossing at the receiving shaft. The layer is composed of medium dense to dense silty sand (SM) with corrected blow counts ranging from 18 to 41 with an average of 30 blows per foot. This layer contains up to 10 percent gravel and between 15 and 30 percent fines. Moisture content will be 10 to 20 percent. This material will behave as fast- to slow-raveling ground.
Gravel with Cobbles	The Gravel with Cobbles layer extends from 15 to 25 feet bgs at the launching shaft and from 19 to 21 feet bgs at the receiving shaft. The layer will be present in the invert of the crossing within the first 10 feet of the crossing, rising to 2 feet above the invert at the receiving shaft. This layer is composed of medium dense to dense gravel with sand (GP) to gravel with silt and sand (GP-GM) and contains up to 20 percent cobbles by volume. Average blow count of this layer is 60 blows per foot. This material will behave as fast- to slow-raveling ground.
Lower Silty Sand	The Lower Silty Sand layer extends below 22 feet bgs at the launching shaft and below 21 feet bgs at the receiving shaft. This layer is composed of medium dense to dense silty sand (SM) with corrected blow counts ranging from 13 to 34 with an average of 24 blows per foot. This layer contains no gravel and contains between 30 and 50 percent fines. This material will behave as fast- to slow-raveling ground.
Groundwater	Groundwater will be encountered at or below elevation 4,736 feet.

4.3 U.S. Highway 6

BH-22-10 was completed approximately 5 feet east of the planned centerline and within the launching shaft footprint; BH-22-11 was completed approximately 20 feet east of the receiving shaft. BH-20-10 and BH-20-11 were completed to a depth of approximately 40.5 and 41 feet, respectively, using a CME 55 drill rig and an HQ casing advancer.

4.3.1 Subsurface Conditions Encountered

Boring BH-22-10 encountered 4.5 feet of sandy lean clay with gravel (CL) with organics and gravelly lean clay with sand (CL). Beneath this layer is 2.5 feet of silt with sand (ML) and an additional 2.5 feet of sandy silty clay (CL-ML). These layers are followed by about 1.5 feet of

sandy lean clay (CL) through which the SPT sampler was pushed. The remaining material encountered during this exploration, to a depth of completion of 40.5 feet bgs, was gravel with silt and sand (GP-GM) with noted possible cobbles.

A 2-foot-thick layer of gravelly lean clay with sand (CL) was encountered at the surface in boring DH-22-11. Below this lies a 2.5-foot-thick layer of gravel with silt and sand (GP-GM), followed by 5 feet of silty sand with gravel (SM) and silty sand (SM). This is followed by a 2.5-foot-thick layer of silty gravel with sand (GM) and a 1-foot-thick layer of sandy silt (ML) and an additional 1.5-foot-thick layer of silty gravel with sand (GM). The remaining material encountered during this exploration, to a depth of completion of 41 feet bgs, was gravel with silt and sand (GP-GM) with noted possible cobbles.

Groundwater was encountered between 39 feet bgs (elevation 4,843.5 feet) at the time of drilling DH-22-10 and 39 feet bgs (elevation 4,846 feet) at the time of drilling DH-22-11.

Gravel and fill material associated with the construction of the nearby UPRR overpass should be expected to be present at this crossing. Cobbles, gravel, sand, silt, and clayey soils are anticipated to be encountered during the tunneling construction.

4.3.2 Baseline Subsurface Conditions

The baseline subsurface soil and groundwater conditions for the US-6 crossing are described below and are illustrated on Figure 2. The transitions between materials shown on Figure 2 are approximate, and in the event of a discrepancy between the information presented in Table 4, Figure 2, and the borings logs and other descriptions contained in the GDR, Table 4 shall take precedence.

TABLE 4
Geotechnical Baseline Conditions for the U.S. Highway 6 Crossing

Layer	Description
Fill	No project borings were advanced within the US-6 embankment fill. Given the steep slope of the embankment, it is anticipated that the fill consists of clayey sand with gravel and sandy clay with gravel, likely locally derived. This material will behave as slow-raveling to firm ground.
Gravelly Clay	The surficial Gravelly Clay layer extends to 4 feet bgs at the launching shaft and to 3 feet bgs at the receiving shaft and is composed of stiff sandy lean clay with gravel (CL) and gravelly lean clay with sand (CL) with corrected blow counts ranging from 2 to 33 with an average of 18 blows per foot. The clay has an average s_u of 1,500 psf. This material will behave as slow-raveling to firm ground.

TABLE 4
Geotechnical Baseline Conditions for the U.S. Highway 6 Crossing

Sandy Silt with Gravel and Cobbles	The Sandy Silt with Gravel and Cobbles layer extends from approximately 4 to 11 feet bgs at the launching shaft and from approximately 3 to 14 feet bgs at the receiving shaft and is composed of silt with sand (ML) and silty sand with gravel (SM) grading to sandy silty clay (CL-ML) and silty gravel with sand (GM) with corrected blow counts ranging from 0 to 53 with an average of 24 blows per foot. The soil's consistency within this layer is variable, ranging from loose and soft to dense and firm. This layer contains between 20 and 80 percent fines and up to 80 percent gravel. The plasticity index of the fines material within this layer is less than 10. This material will behave as fast- to slow-raveling ground. This layer will be encountered in the upper half of the crossing at the launching shaft, after which it will grade toward the invert as the tunnel drive continues, resulting in a full face at the receiving shaft.
Gravel and Cobbles	The Gravel and Cobbles layer begins at approximately 11 feet bgs at the launching shaft and at approximately 14 feet bgs at the receiving shaft, and is composed of dense to very dense gravel with silt and sand (GP-GM) with cobbles with corrected blow counts ranging from 24 to 97 with an average of 61 blows per foot. This layer contains between 40 and 60 percent gravel, between 30 and 50 percent sand, and up to 15 percent fines. This material will behave as fast- to slow-raveling ground. This layer will be encountered in the lower 3 feet of the face near the launching shaft before it grades toward the invert as the tunnel drive continues. At the receiving shaft it will be present 1 foot above the invert.
Groundwater	Groundwater will be encountered at or below elevation 4,850 feet.

4.4 Union Pacific Railroad

Boring BH-22-18 was completed approximately 54 feet south of the receiving shaft to a depth of 26.5 feet using a CME 75 drill rig with a hollow-stem auger.

4.4.1 Subsurface Conditions Encountered

Boring BH-22-18 encountered 4.5 feet of lean clay with sand (CL), followed by a 1.5-foot-thick layer of fat clay (CH). These layers are underlain by interbedded layers of fine and coarse material, including 1 foot of silt with trace sand (ML), 1.5 feet of silty sand (SM), 2 feet of lean clay with silty sand lenses (CL), and 2 feet of silt with trace sand (ML). Underlying these layers is a thin (<1-foot-thick) layer of clayey gravel with sand (GC) followed by 2.5 feet of sand with silt and gravel (SP-SM). The remaining material encountered during this exploration, to a depth of completion of 26.5 feet bgs, was gravel with silt and sand (GP-GM).

Groundwater was encountered at a depth of 21.5 feet bgs (elevation 4,893 feet) at the time of drilling DH-22-18.

Gravel layers associated with fill materials from the gravel ballast beneath the railroad tracks due to construction of the railroad should be expected to be present at this crossing. Gravel, sand, silt, and clayey soils are anticipated to be encountered during the tunneling construction.

4.4.2 Baseline Subsurface Conditions

The baseline subsurface soil and groundwater conditions for the UPRR crossing are described below and are illustrated on Figure 3. The transitions between materials shown on Figure 3 are approximate, and in the event of a discrepancy between the information presented in Table 5, Figure 3, and the borings logs and other descriptions contained in the GDR, Table 5 shall take precedence.

SPT values were collected during drilling and are reported here within the gravel with silt and sand (with cobbles) layers; however, SPT values are not particularly reliable in soils with gravel and oversized material because the split-spoon sampler could hit a cobble, boulder, or piece of gravel yielding artificially high N_{60} values. Grain size distribution and Atterberg limits are included where available.

TABLE 5
Geotechnical Baseline Conditions for the Union Pacific Railroad Crossing

Layer	Description
Fill	No project borings were advanced within the US-6 embankment fill nor the adjacent flood control berm that protects the tracks. Given the steep slope of the embankment, it is anticipated that the fill consists of clayey sand with gravel and sandy clay with gravel, likely locally derived. This material will behave as slow-raveling to firm ground.

TABLE 5
Geotechnical Baseline Conditions for the Union Pacific Railroad Crossing

Clay with Sand	The surficial Clay with Sand layer extends to about 7 feet bgs at the receiving shaft and to about 4 feet bgs at the launching shaft and is composed of stiff lean clay with sand (CL) with corrected blow counts ranging from 24 to 33 with an average of 29 blows per foot. The clay has an average s_u of 4,000 psf. This material will behave as firm ground.
Fat Clay	The underlying Fat Clay layer extends from approximately 7 to 8 feet bgs at the receiving shaft and from approximately 4 to 5 feet bgs at the launching shaft and is composed of very stiff fat clay (CH). The plasticity index is greater than 40 and contains less than 10 percent sand and more than 90 percent fines. The clay has an average s_u of 4,500 psf. This material will behave as firm ground.
Silt with Sand and Clay	The Silt with Sand and Clay layer extends from approximately 8 to 13 feet bgs at the receiving shaft and from approximately 5 to 10 feet bgs at the launching shaft and is composed of interbedded layers of very dense silt with trace sand (ML), firm lean clay (CL), and dense silty sand (SM) with corrected blow counts ranging from 39 to 53 with an average of 46 blows per foot. The plasticity index is less than 10, contains less than 5 percent gravel, between 10 and 20 percent sand, and about more than 80 percent fines. This layer will be encountered up to 1 foot below the tunnel crown near the launching shaft. The clay has an average s_u of 4,000 psf. This material will behave as firm to slow-raveling ground.
Sand and Gravel with Silt	The Sand and Gravel with Silt layer begins at approximately 13 feet bgs at the receiving shaft and at approximately 10 feet bgs at the launching shaft and is composed of clayey gravel with sand (GC) grading to very dense sand with silt and gravel (SP-SM) to dense to very dense gravel with silt and sand (GP-GM) with corrected blow counts ranging from 48 to 100 with an average of 74 blows per foot. This layer contains between 50 and 70 percent gravel, between 20 and 40 percent sand, and up to 10 percent fines and is anticipated to comprise the majority of the full face of the tunnel excavation. This material will behave as fast- to slow-raveling ground.
Groundwater	Groundwater will be encountered at or below elevation 4,895 feet, within the invert of the shafts.

5.Construction Considerations

5.1 General

5.1.1 Work Area Constraints

All shaft construction activities must be completed within established easements shown on the contract drawings. Shaft construction cannot encroach into UPRR ROW. The contractor is responsible for protecting existing utilities and structures and for restoring the ground surface to its original condition following construction.

5.1.2 Right-of-Way Permits

I-15 and US-6 are UDOT ROWs; the contractor must comply with all requirements of UDOT permits, including the provision to provide traffic control whenever required for construction and monitoring purposes. Permit conditions also restrict the obstruction of traffic lanes and have very specific work windows associated with the obstructions. The contractor must consider these permit requirements when identifying suitable trenchless construction methods and locating, sizing, and supporting the receiving shafts.

UPRR has additional requirements related to protection of their rail facilities. The contractor must review the conditions of the permit and comply with specific requirements, such as the requirement to work continuously while within their ROW, and to hire and coordinate flaggers.

5.2 Launching and Receiving Shafts

5.2.1 Shaft Excavation Methods

The contractor is responsible for the selection of the appropriate launching and receiving shaft support systems and must consider the presence of sands and gravels with varying amounts of fines and cobbles in selecting the appropriate support system. In addition, the contractor should consider the nature and relative stiffness and density of the site soils, shaft size requirements, temporary easements, adjacent facilities, jurisdictional shoring requirements, and schedule constraints when selecting a shaft construction method.

5.2.2 Launching and Receiving

Groundwater is anticipated to be at or below the base of the shafts at all crossings; however, given the presence of sands, gravels, and cobbles (as defined in the baseline statements), ground stabilization on the outside of the shafts will be necessary for launching and receiving of the tunneling equipment. The ground stabilization must be completed prior to commencement of tunneling activities so that grouting activities do not inhibit the tunneling operations and the strength of the stabilization will be compatible with the tunneling operations. The contractor must pay particular attention to maintaining stability of surficial soils during launch at the US-6 crossing to avoid destabilizing the roadway embankment.

If the contractor elects to incorporate a "soft eye" or an "unreinforced window" in the design of the shoring system, through which a tunnel can penetrate, the contractor must consider that the equipment will have difficulty excavating high-strength materials. The soft eye must be designed to prevent damage to the casing, tunnel boring machine (TBM), or auger as it is launched or received.

5.2.3 Identified Shaft Risks

Sand and gravel with varying percentages of fines and cobbles will be encountered at all shaft locations. Previous construction in similar soils has shown that difficulties can arise during sunken caisson shaft construction in dense to very dense sands, gravel, and cobbles, significantly impeding construction progress. If soldier piles and lagging are used, the contractor must anticipate that predrilling will be required to permit installation of the piles to full depth. If stacked trench boxes are used, the contractor is alerted to the need to support the soils around and above the launch and reception of the tunnel.

Consideration must also be given to site drainage. In no case can runoff cause erosion of the embankment or shaft slopes. Runoff must be directed around the shafts to prevent flooding and/or transport of material into the shafts.

For excavations using earth slopes, consideration must be given to the raveling and running behavior of the sands and gravels. Slopes must be protected in accordance with all applicable U.S. Occupational Safety and Health Administration standards.

5.3 Tunneling Methods

The equipment for installation of the pipe should be compatible with the baselined ground conditions at the site and fully capable of meeting the construction needs of the project. The contractor will provide for addressing fast-raveling soil conditions as well as the presence of cobbles, as these may produce unacceptable levels of surface settlement.

Tunneling operations will be controlled by the contractor to avoid pipe damage, displacement of the pipe from the specified alignment grade, damage to adjacent structures and utilities, and settlement or heaving of the ground surface.

5.3.1 Auger Boring Excavation

The contractor will control auger boring operations to avoid excessive lost ground as this may produce settlements in excess of allowable limits or affect jacking procedures and forces. Whenever the leading edge of the bore is in ground conditions that might not temporarily support an open face or otherwise might threaten overlying facilities that must be protected, the auger will not be permitted to extend beyond the cutting edge of the casing. The auger boring machine should be capable of excavating the baselined cobbles, and the auger size and auger pitch should be selected to efficiently excavate through the ground conditions baselined herein. The cutting tools must be able to resist wearing to maintain proper clearances between the surrounding soils and the casing.

Up to five interventions (full auger removal) must be anticipated at each of two crossings (I-15 and US-6) to remove nests of baselined cobbles from the casing and augers at each of the crossings.

5.3.2 Tunnel Boring Machine Excavation

An open-face rotary-wheel TBM can be used to construct the tunnel crossings. This method was selected for its relative low risk to workers and its cost effectiveness. The TBM can be used with pipe jacking to directly install a steel casing or in a conventional tunneling approach for the UDOT crossings to install initial ground support.

The contractor will control TBM operations to avoid excessive lost ground, as this may produce settlements in excess of allowable limits or affect jacking procedures and forces. The TBM should be capable of excavating the baselined cobbles and boulders, and the cutterhead openings and tooling should be selected to efficiently excavate through the ground conditions baselined herein. The cutting tools must be able to resist wearing to maintain proper clearances between the surrounding soils and the casing.

Up to three interventions must be anticipated at each of two crossings (I-15 and US-6) to remove nests of baselined cobbles from the cutterhead and mucking system at each of the crossings.

5.3.3 Contact Grouting

To minimize settlement, a program of grouting is specified. The grouting will be completed immediately after the completion of the casing or initial ground support installation and will be implemented from within the tunnel using grout ports installed directly into the steel lining or ground support. The timely installation of grout is particularly important given the presence of fine soils above granular soils at a number of the crossing locations.

5.3.4 Carrier Pipe Welding

Initial ground support and casing sizes were selected to accommodate welding of the carrier pipe within the launching shaft. If conventional tunneling is elected to install initial ground support, the contractor is responsible for fabricating a system of guide rails and pipe supports suitable for supporting the weight of the carrier pipe, allowing it to be pushed into the tunnel, and finally grouted into place.

5.3.5 Settlement Monitoring

Settlement monitoring is required as described in the technical specifications. At I-15, a system of surface and subsurface monitoring points are specified to confirm appropriate levels of ground loss prior to entering the UDOT ROW.

The maximum allowable value of settlement for UPRR tracks is 0.75 inch over a 62-foot chord length centered on the tunnel centerline, based on *Code of Federal Regulations* Title 49 Part 213—Track Safety Standards for a Class V track. The maximum allowable value of settlement for the I-15 and US-6 crossings is on the order of 1 inch.

5.4 Muck Disposal

All material excavated from the tunnels must be removed and disposed of offsite at locations in compliance with federal, state, and local standards. This includes any additives, polymers, and bentonite used in tunnel construction and lubrication.

SECTION 6

6.References

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Figures

SECTION 02 41 00
DEMOLITION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): Guideline K, Containers for Recovered Non-flammable Fluorocarbon Refrigerants.
2. American National Standards Institute (ANSI): A10.6, Safety Requirements for Demolition Operations.
3. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
   a. Part 61—National Emission Standards for Hazardous Air Pollutants.
   b. Part 82—Protection of Stratospheric Ozone.
   c. Part 273—Standards for Universal Waste Management.
4. Occupational Safety and Health Administration (OSHA), U.S. Code of Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety and Health Regulations for Construction.
5. United States Bureau of Reclamation (USBR) – Safety and Health Standards Manual.

1.02 DEFINITIONS

A. ACM: Asbestos-containing material.

B. Demolition: Dismantling, razing, destroying, or wrecking of any fixed building or structure or any part thereof. Demolition also includes removal of pipes, manholes tanks, conduit, and other underground facilities, whether as a separate activity or in conjunction with construction of new facilities.

C. Modify: Provide all necessary material and labor to modify an existing item to the condition indicated or specified.

D. Relocate: Remove, protect, clean and reinstall equipment, including electrical, instrumentation, and all ancillary components required to make the equipment fully functional, to the new location identified on Drawings.

E. Renovation: Altering a facility or one or more facility components in any way.

F. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste; such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

G. Universal Waste Lamp: In accordance with 40 CFR 273, the bulb or tube portion of an electric lighting device, examples of which include, but are not limited to, fluorescent, high-intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps.

H. Universal Waste Thermostat: A temperature control device that contains metallic mercury in an ampule attached to a bimetal sensing element, and mercury-containing ampules that have been removed from these temperature control devices in compliance with the requirements of 40 CFR 273.

1.03 SUBMITTALS

A. Informational Submittals:

1. Submit proposed Demolition Plan, in accordance with requirements specified herein, for approval before such Work is started.
2. Submit copies of any notifications, authorizations and permits required to perform the Work.
3. Copies of reports and other documentation required for abandoning wells.
4. Submit a shipping receipt or bill of lading for all containers of ozone depleting substance (ODS) shipped.
5. Submit a shipping receipt or bill of lading for all containers of ACM shipped.
6. Submit a shipping receipt or bill of lading for all universal waste shipped.

1.04 REGULATORY AND SAFETY REQUIREMENTS

A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.

B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor's safety requirements shall conform to ANSI A10.6.

C. Furnish timely notification of this demolition/renovation project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.05 DEMOLITION PLAN

A. Demolition Plan shall provide for safe conduct of the Work and shall include:

1. Detailed description of methods and equipment to be used for each operation;
2. The Contractor's planned sequence of operations, including coordination with other work in progress;
3. Procedures for removal and disposition of materials specified to be salvaged;
4. Disconnection schedule of utility services.

B. Include statements affirming Contractor inspection of the existing roof deck, floors, walls, and framing members, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work if applicable for Project Work.

1.06 SEQUENCING AND SCHEDULING

A. The Work of this Specification shall not commence until Contractor's Demolition Plan has been accepted by Engineer.

B. Include the Work of this Specification in the progress schedule, as specified in Section 01 32 00, Construction Progress Documentation.

1.07 USE OF EXPLOSIVES

A. Not permitted.

1.08 ENVIRONMENTAL PROTECTION

A. Comply with federal and state regulations.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

A. Facilities:

1. Buildings and adjacent designated areas scheduled for complete demolition are as shown.
2. Portions of buildings and other areas scheduled for selective demolition, partial demolition, and renovation Work are as shown.

B. Structures:

1. Existing above grade structures indicated shall be removed to 3 feet minimum below grade unless otherwise indicated.
2. Interior walls, other than retaining walls and partitions, shall be removed as shown.
3. Partition walls shall be removed as shown.
4. Core drill concrete slabs and other concrete improvements scheduled to remain in place below ground, or break holes at the structure's lowest point to allow water to freely migrate through.
5. Sidewalks, curbs, gutters and street light bases shall be removed as indicated.

C. Substructure: Extract conflicting existing pilings prior to driving new piles.

D. Utilities and Related Equipment:

1. Notify Owner or appropriate utilities to turn off affected services at least 48 hours before starting demolition or renovation activities.
2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
3. When utility lines are encountered that are not indicated on Drawings, notify Owner prior to further work in that area.
4. Remove meters and related equipment and deliver to a location as determined by the Owner.
5. Excavate and remove utility lines serving buildings to be demolished to a distance of 5 feet beyond the outside perimeter of the demolition.
6. Provide a permanent leak-proof closure for water and gas lines.
7. Plug sewer lines with concrete to a minimum plug length of 2 feet to prevent groundwater infiltration.

E. Paving and Slabs:

1. Remove concrete and asphaltic concrete paving and slabs including aggregate base as indicated.
2. Provide neat sawcuts at limits of pavement removal as indicated.

F. Concrete:

1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that

the broken area is concealed in the finished Work, and the remaining concrete is sound.

2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16 inch. Rebar and small embeds at existing concrete may be required to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on Drawings.
4. At submerged locations not to receive new concrete, paint exposed rebar or metal embed ends with System No. 18a per Section 09 90 00, Painting and Coating.

G. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include:
   a. Fill holes and depressions caused by previous physical damage or left as a result of removals in existing exposed elements like walls with an approved patching material, applied in accordance with the manufacturer's printed instructions.

H. Air-Conditioning Equipment:

1. Remove air-conditioning equipment without releasing chlorofluorocarbon refrigerants to the atmosphere in accordance with the Clean Air Act Amendment of 1990.
2. Recover all refrigerants prior to removing air-conditioning equipment and dispose of as specified in Paragraph Ozone Depleting Substances (ODS).
3. Turn in salvaged Class I ODS refrigerants as specified in Article Specialized Salvage.

I. Cylinders and Canisters: Remove all fire suppression system cylinders and canisters and dispose as specified in Paragraph Ozone Depleting Substances (ODS).

J. Door Locksets: Remove all locksets from all doors indicated to be removed and disposed of. Turn locksets over to Owner immediately after their removal.

K. Electrical:

1. Cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4 inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on the Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.
4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.
5. Raceways and cabling not scheduled for reuse.
6. Inaccessibly Concealed: Cut off and abandon in place.
7. Exposed or Concealed Above Accessible Ceilings: Remove.
8. Raceways and Cabling Scheduled for Future Use: Cap/seal and tag.
9. Relocating Equipment: Extend existing wiring or run new wiring from the source.
10. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
11. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
12. Provide new typewritten panelboard circuit directory cards.

L. Universal Waste Lamps and Thermostats: Manage, contain, package, and label in strict accordance with 40 CFR 273.

3.02 PROTECTION

A. Building Occupancy: Refer to Section 01 31 13, Project Coordination, for specific requirements related to concurrent occupancy of facilities to be partially demolished.

B. Dust and Debris Control:

1. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.

2. Vacuum and dust the Work area daily.
3. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to vehicular traffic.

C. Traffic Control Signs: Where pedestrian and driver safety is endangered in the area of removal Work, use traffic barricades with flashing lights.

D. Existing Work:

1. Survey the site and examine Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.
5. Do not overload pavements to remain.

E. Weather Protection: For portions of the building scheduled to remain, protect building interior and materials and equipment from weather at all times. Where removal of existing roofing is necessary to accomplish the Work, have materials and workmen ready to provide adequate and temporary covering of exposed areas so as to ensure effectiveness and to prevent loss.

F. Trees: Protect trees within the Site that might be damaged during demolition and are indicated to be left in place, by a 6-foot-high fence. The fence shall be securely erected a minimum of 5 feet from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the Work shall be replaced in kind, as approved by the Engineer.

G. Facilities:

1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated,

provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.

2. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
3. Protect all facility elements not scheduled for demolition.
4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.

H. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
2. Provide temporary barricades and other forms of protection to protect Owner's personnel and the general public from injury due to demolition Work.
3. Provide protective measures as required to provide free and safe passage of Owner's personnel and the general public to occupied portions of the structure.

3.03 BURNING

A. The use of burning at the Site for the disposal of refuse and debris will not be permitted.

3.04 RELOCATIONS

A. Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Clean all items to be relocated prior to reinstallation, to the satisfaction of Engineer. Repair items to be relocated which are damaged or replace damaged items with new undamaged items as approved by Engineer.

3.05 BACKFILL

A. Do not use demolition debris as backfill material.

B. Fill excavations, open basements and other hazardous openings to existing ground level or foundation level of new construction in accordance with Section 31 23 23, Fill and Backfill.

3.06 TITLE TO MATERIALS

A. With the exception of the following listed salvaged equipment and materials, all items designated to be removed shall become the property of Contractor:

1. None.

3.07 DISPOSITION OF MATERIAL

A. Do not remove equipment and materials without acceptance of Contractor's Demolition/Renovation Plan by Engineer.

B. Salvage equipment and material to the maximum extent possible.

C. Remove salvaged items designated as the property of Owner in a manner to prevent damage and pack or crate to protect the items from damage while in storage or during shipment. Properly identify containers as to contents.

D. Repair or replace, at the discretion of Engineer, items designated as the property of the Owner damaged during removal or storage.

E. Deliver salvaged items that are designated as the property of Owner to a storage site as directed on the Site.

F. Owner will not be responsible for the condition or loss of, or damage to, property scheduled to become Contractor's property after Engineer's authorization to begin demolition or renovation. Materials and equipment shall not be viewed by prospective purchasers or sold on the Site.

G. Store Contractor owned salvaged items where approved by Owner and remove them from Owner's property before completion of the Contract. Materials and equipment shall not be either viewed by prospective purchasers or sold on the Site.

3.08 REUSE OF MATERIALS AND EQUIPMENT

A. Remove and store materials and equipment listed in Article Title To Materials to be reused or relocated to prevent damage, and reinstall as the Work progresses.

B. Properly store and maintain equipment and materials in same condition as when removed.

C. Store equipment and material designated to be reused in a location designated by Owner.

D. Equipment and material designated to be reused shall be cleaned, serviced and checked for proper operability before being put back into service.

E. Engineer will determine condition of equipment and materials prior to removal.

3.09 SPECIALIZED SALVAGE

A. Historical Items:

1. Remove in a manner to prevent damage.
2. The following historical items shall be delivered to Owner for disposition:
   a. None.

B. Ozone Depleting Substances (ODS):

1. Class I and Class II ODS are defined in Section 602(a) and (b), of The Clean Air Act. Prevent discharge of Class I and Class II ODS to the atmosphere. Place recovered ODS in cylinders meeting AHRI Guideline K suitable for the type ODS (filled to no more than 80 percent capacity) and provide appropriate labeling.
2. Dispose of all Class I and Class II ODS refrigerants in accordance with the Clean Air Act Amendment of 1990.
3. Products, equipment and appliances containing ODS in a sealed, self-contained system (such as, residential refrigerators and window air conditioners) shall be disposed of in accordance with 40 CFR 82.

C. Fire Suppression Containers: Fire suppression system cylinders and canisters with electrical charges or initiators shall be deactivated prior to shipment. Also, safety caps shall be used to cover exposed actuation mechanisms and discharge ports on these special cylinders.

3.10 UNSALVAGEABLE MATERIAL

A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of in the following manner and location.

1. Off the Site unless indicated otherwise.

B. Combustible material shall be disposed of in a sanitary fill.

C. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.11 CLEANUP

A. Debris and rubbish shall be removed from basement and similar excavations. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 301, Specifications for Structural Concrete.
   b. 506.2, Specification for Shotcrete.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C293/C293M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading.
   j. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   l. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   m. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
   n. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   o. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

p. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
q. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
r. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
s. D4259, Standard Practice for Abrading Concrete.
t. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

3. NSF International (NSF): 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.

E. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

F. Rebound: Shotcrete material, mostly aggregates, that bounce off a surface against which shotcrete was projected.

G. Shotcrete: Mortar pumped through hose and projected at high velocity.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each material supplied.
2. Samples: Mesh reinforcement and mesh anchor.
3. Drawings supplemented by photographs indicating location, size, estimated quantity, and proposed repair mortar for each repair location in existing concrete.
4. Drawings indicating results of sounding for hollow areas including location, size, and estimated quantity of hollow-sounding areas for each repair location.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Mesh manufacturer's installation instructions and allowable load criteria.
3. Written description of equipment proposed for concrete removal and surface preparation.
4. Certificates:
   a. Shotcrete Nozzleman: Current ACI Certification for each proposed nozzleman.
   b. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that proposed repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to weather and water.
   c. Mortar Manufacturer's Certificate of Proper Installation.
5. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Repair mortar system manufacturer's representative.
   c. Independent Testing Laboratory.
6. Repair mortar system manufacturer's proposed modified test procedures for ASTM C109/C109M, ASTM C882/C882M, and ASTM C157/C157M test methods.
7. Field and laboratory test reports.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator:
   a. For Repair System A—Shotcrete Mortar, trained and experienced applicator recognized or certified by repair mortar system manufacturer.

b. For Repair System B—Low-Pressure Spray Mortar, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.

2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

C. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Technical representative for repair material manufacturer.
   d. Engineer.
2. Schedule and conduct prior to completing any repairs. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
   a. Review of field conditions. Conduct field observations of Work to be performed.
   b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project-specific repair method recommendations.
   c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
   d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM A—SHOTCRETE MORTAR

A. Mortar Materials:

1. Blend of selected portland cements, microsilica, and specially graded aggregates and fibers applicable for vertical and overhead surfaces.

2. Materials shall not contain asbestos, chlorides, nitrates, added gypsum, added lime, or high aluminum cements.
3. Noncombustible before and after cure.
4. Furnish in factory proportioned unit.
5. Workability from 1/4 inch in depth and greater.

B. Mixed Mortar Properties:

1. Working Time: 5 minutes to 10 minutes.
2. Finishing Time: 10 minutes to 20 minutes.
3. Color: Dark gray.

C. Cured Mortar Properties:

1. Compressive strength for 2-inch cubes in accordance with ASTM C109/C109M, or 3-inch cubes in accordance with manufacturer's modification to ASTM C109/C109M:
   a. 7 Days: 6,000 psi minimum.
   b. 28 Days: 7,000 psi minimum.
2. Flexural Strength (Modulus of Rupture), ASTM C78/C78M or ASTM C348 (Modified) at 28 Days: 1,100 psi minimum.
3. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 400 psi minimum.
4. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum.
5. Mortar shall not produce a vapor barrier.

2.02 REPAIR SYSTEM B—LOW-PRESSURE SPRAY MORTAR

A. One-component or two-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
7. System shall not produce a vapor barrier.

8. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
9. Free of chlorides and other chemicals causing corrosion.

2.03 REPAIR SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR

A. Polymer-modified, one-component or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1 square foot in area or less.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and belowgrade repairs.

2.04 REPAIR SYSTEM D—SITE-MIXED PORTLAND-CEMENT MORTAR

A. Mortar Materials:

1. Use same materials as concrete to be repaired with no coarse aggregate, per Section 03 30 00, Cast-in-Place Concrete. Use of 3/8-inch nominal pea gravel acceptable where repairs are in excess of 1 inch deep.
2. For repairs to exposed concrete, make trial batches to check color compatibility of repair mortar with existing surrounding concrete.
3. When repair is too dark, substitute white portland cement for part of the gray portland cement to produce desired color closely matching color of surrounding concrete.

2.05 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.06 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03 21 00, Steel Reinforcement.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer's recommendations.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

1. Manufacturers and Products:
   a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
   b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

2.07 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Use where recommended by repair system manufacturer.
2. Bonding agent shall not produce a vapor barrier.
3. Compatible with and from same manufacturer as the repair system used.

2.08 EVAPORATION RETARDANT

A. As specified in Section 03 39 00, Concrete Curing.

2.09 CURING COMPOUND

A. As specified in Section 03 39 00, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. The Guide to Concrete Repair published by the United State Department of the Interior, Bureau of Reclamation Technical Service Center will be used as a guide for repair materials and methods as directed by the Engineer. The repair guide is available for download on the Bureau of Reclamation website.

B. Repair of surfaces shall be repaired to the satisfaction of the Engineer.

C. New concrete which cannot be repaired to the satisfaction of the Engineer will be rejected and require removal and replacement at the expense of the Contractor.

D. Develop repair techniques with material manufacturer on mockup panels prior to starting actual repair work and show how finish color will blend with adjacent surfaces. Obtain approval from the Engineer.

E. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to the Engineer.

3.02 APPLICATION

A. General:

1. Repair System A: Large areas and number of repair areas.
2. Repair System B: Medium to large areas and number of repair areas.
3. Repair System C: Small and limited areas and number of repair areas.
4. Repair System D: Small to large areas.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.

B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.

1. Use 8,000 psi minimum high-pressure water blasting machine as required for Site conditions.
2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. For existing structures, extent of concrete removal as shown on Drawings.
4. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer's printed instructions.

K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

A. Provide steel reinforcement when existing reinforcement is not exposed, and when mortar application is more than 3 inches deep, unless otherwise shown on Drawings.

B. Replace deteriorated steel reinforcement with new steel reinforcement equivalent in cross-sectional area to original steel reinforcement.

C. Install mesh anchors in accordance with mesh manufacturer's instructions.

D. Fasten steel reinforcement to mesh anchors with tie wire to prevent from moving during placement of repair mortar.

E. Lap reinforcement mesh a minimum of one mesh spacing and securely fasten mesh to mesh anchors, or to reinforcement fastened to mesh anchors, with tie wire at intervals no more than 12 inches to prevent movement during application of repair mortar.

F. Coat exposed new and existing steel reinforcement and reinforcement mesh with cementitious reinforcement coating at same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

3.05 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used.

3.06 REPAIR SYSTEM A—SHOTCRETE MORTAR PLACEMENT

A. Apply shotcrete mortar in accordance with manufacturer's instructions.

B. Do not reuse rebound materials.

C. Apply mortar using dry mix process, in accordance with ACI 506.2.

D. Shotcrete mortar shall emerge from nozzle in a steady, uninterrupted flow. If flow becomes intermittent, direct flow away from the Work until flow of mortar becomes constant.

E. Applied Shotcrete Mortar: Minimum thickness of 1-1/2 inches to 2 inches of cover over existing reinforcement, or to level of surrounding concrete surface, whichever results in thicker coat.

F. Nozzle Position: Hold nozzle approximately at right angles to and at a distance from surface in accordance with shotcrete repair mortar system manufacturer's instructions for type of application, nozzle, and air pressure used.

G. Steel Reinforcement Encasement:

1. Modify procedure of shooting shotcrete mortar to better direct material around reinforcement bars.
2. Prevent shotcrete mortar from building up on reinforcement steel when shooting on, around, through, and behind steel to eliminate voids.
3. Provide dense void-free encasement of reinforcement steel.

H. Shotcreting More than One Layer: In accordance with shotcrete repair mortar system manufacturer's printed instructions.

I. Slice off excess material with a wire screed approximately 5 minutes to 10 minutes after initial set.

J. Apply finish to exposed shotcrete mortar surface to match existing surface. Apply full strength evaporation retardant.

K. Rebound Removal: Continuously throughout shotcrete mortar application, remove rebound, sand, and miscellaneous debris, and dispose offsite at an approved disposal facility.

L. Cure as specified in Article Curing.

3.07 REPAIR SYSTEM B—LOW-PRESSURE SPRAY MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Bonding Agent:

1. Use bonding agent when manufacture required for hand applied areas, in accordance with repair mortar manufacturer's instructions.

2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.

D. Work mortar firmly and quickly into repair area.

E. Finish repair mortar to match adjacent concrete surface.

F. Provide evaporation retardant at full strength.

G. Cure as specified in Article Curing.

3.08 REPAIR SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

D. Finish repair mortar to smooth even surface to match adjacent concrete surface.

E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.09 REPAIR SYSTEM D—SITE-MIXED PORTLAND-CEMENT REPAIR MORTAR PLACEMENT

A. Prepare mortar to a stiff consistency with no more mixing water necessary for handling and placing.

B. Mix site-mixed portland-cement repair mortar in accordance with requirements of ACI 301.

C. Apply scrub coat of mortar worked into existing substrate surface with a stiff bristled brush. Use of epoxy resin bonding agent is not acceptable.

D. Work mortar firmly and quickly into repair area before scrub slurry coat begins to dry.

E. Finish repair mortar to match adjacent concrete surface.

3.10 CURING

A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.

B. Cure in accordance with repair mortar manufacturer's printed instructions.

C. Where permitted by repair mortar manufacturer's printed instructions, commence water curing after repair mortar system application and when curing will not cause erosion of mortar.

D. Continuously water cure repair mortar system for a period of 7 days.

E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.

F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.11 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

3.12 MANUFACTURER'S SERVICES

A. Provide repair mortar system manufacturer's representative at Site to review acceptability of surface preparation, mixing and installation assistance, training of repair mortar system applicators, inspection, and Certification of Proper Installation.

3.13 CLEANING

A. Remove overshot repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

SECTION 03 01 33
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T277, Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   j. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
   k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   l. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   m. C779/C779M, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
   n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   o. C928/C928M, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs.

p. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
q. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
r. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
s. D638, Standard Test Method for Tensile Properties of Plastics.
t. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
u. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
v. D4259, Standard Practice for Abrading Concrete.
w. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

3. NSF, International (NSF): 61, Standard for Drinking Water System Components – Health Effects.
4. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40: 52.254, Approval and Promulgation of Implementation Plans.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. High-Pressure Water Blasting (sometimes referred to as hydro-demolition): Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each material supplied.
2. Drawings supplemented by photographs indicating location, size, estimated quantity, and proposed repair mortar system for each repair location in existing concrete.
3. Drawings indicating results of sounding for hollow areas including location, size, estimated quantity, of hollow-sounding areas for each repair location.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
   a. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements, that proposed repair mortar systems meet requirements of ASTM C928/C928M.
   b. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on horizontal surfaces that are exposed to weather and/or water, or receive traffic.
   c. Mortar Manufacturer's Certificate of Proper Installation.
4. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Independent Testing Laboratory.
5. Field and laboratory test results.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.
2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

C. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Technical representative for repair material manufacturer.
   d. Engineer.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
   a. Review of field conditions. Conduct field observations of the Work to be performed.
   b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project specific repair method recommendations.
   c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
   d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR MORTAR SYSTEM NO. 1—MAGNESIUM PHOSPHATE REPAIR MORTAR

A. One-component or two-component, magnesium-ammonium-phosphate concrete mortar.

B. Compressive Strength, ASTM C109/C109M modified:

1. 1 Hour: 2,000 psi minimum.
2. 3 Hours: 5,000 psi minimum.
3. 1 Day: 6,000 psi minimum.
4. 28 Days: 7,500 psi minimum.

C. Flexural Strength, ASTM C78/C78M Modified (3-inch by 4-inch by 16-inch prism) at 1 Day: 550 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 7 Days: 4.18 by 10^6 psi minimum.

E. Freeze-thaw Resistance and Resistance to Deicing Chemicals, ASTM C666/C666M, Procedure A, at 300 Cycles: 80 percent RDM minimum.

F. Sulfate Resistance, ASTM C1012/C1012M, Length Change after 52 Weeks: 0.09 percent maximum.

G. Application Temperature Range: 20 degrees F to 85 degrees F for normal weather applications and 85 degrees F to 100 degrees F for hot weather applications.

2.02 REPAIR MORTAR SYSTEM NO. 2—HIGH EARLY STRENGTH REPAIR MORTAR

A. One-component or two-component, fast-setting, high early strength repair mortar.

B. Compressive Strength, ASTM C109/C109M:

1. 2 Hours: 1,500 psi minimum.
2. 1 Day: 4,500 psi minimum.
3. 7 Days: 8,000 psi minimum.
4. 28 Days: 9,000 psi minimum.

C. Flexural Strength, ASTM C348:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,000 psi minimum.
3. 28 Days: 1,100 psi minimum.

D. Modulus of Elasticity, ASTM C469:

1. 1 Day: 3.8 by 10^6 psi minimum.
2. 28 Days: 4.5 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M (Modified):

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 2,900 psi minimum.
3. 28 Days: 3,100 psi minimum.

F. Splitting Tensile Strength, ASTM C496/C496M:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,200 psi minimum.
3. 28 Days: 1,300 psi minimum.

G. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 98 percent RDM.

H. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 or AASHTO T277, 28 Days: 960 coulombs maximum.

2.03 REPAIR MORTAR SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

A. One-component or two-component cement-based, flowable, shrinkage compensated repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 6,000 psi minimum.
3. 28 Days: 8,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 770 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M Modified:

1. 7 Days: 2,150 psi minimum.
2. 28 Days: 3,000 psi minimum.

F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97.0 percent RDM.

G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.

H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.

2.04 REPAIR MORTAR SYSTEM NO. 4—METALLIC AGGREGATE REPAIR MORTAR

A. One-component or two-component cement-based, flowable, metallic-aggregate repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 5,000 psi minimum.
2. 7 Days: 8,800 psi minimum.
3. 28 Days: 12,000 psi minimum.

C. Abrasion Resistance, ASTM C779/C779M, Procedure A: Eight times more wear resistance than plain concrete, 0.017 inch maximum.

D. Density: 215 pounds per cubic foot.

2.05 REPAIR MORTAR SYSTEM NO. 5—POLYMER MODIFIED REPAIR MORTAR

A. One-component or two-component, fast-setting, polymer modified cementitious based repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 5,000 psi minimum.
3. 28 Days: 7,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 1,500 psi minimum.

D. Slant Shear Bond Strength, ASTM C882/C882M Modified at 28 Days: 2,000 psi minimum.

E. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.

F. Abrasion Resistance Depth of Wear, ASTM C779/C779M, Procedure A, at 60 Minutes: 0.033 inch maximum.

G. Drying Shrinkage, ASTM C157/C157M Modified, at 28 Days: 0.09 percent maximum.

H. Rapid Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 28 Days: Under 850 coulombs maximum.

2.06 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03 21 00, Steel Reinforcement.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer's recommendations.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

1. Manufacturers and Products:
   a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
   b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

2.08 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Use where recommended by repair system manufacturer.
2. Bonding agent shall not produce a vapor barrier.
3. Compatible with, and from same manufacturer as the, repair mortar system used.

2.09 EVAPORATION RETARDANT

A. As specified in Section 03 39 00, Concrete Curing.

2.10 CURING COMPOUND

A. As specified in Section 03 39 00, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. The Guide to Concrete Repair published by the United State Department of the Interior, Bureau of Reclamation Technical Service Center will be used as a guide for repair materials and methods as directed by the Engineer. The repair guide is available for download on the Bureau of Reclamation website.

B. Repair of surfaces shall be repaired to satisfaction of the Engineer.

C. New concrete which cannot be repaired to the satisfaction of the Engineer will be rejected and require removal and replacement at the expense of the Contractor.

D. Develop repair techniques with material manufacturer on mockup panels prior to starting actual repair work and show finish color will blend with adjacent surfaces. Obtain approval from the Engineer.

E. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to the Engineer.

3.02 APPLICATION

A. General:

1. Repair Mortar System No. 1: Patches, joints, and overlays 1/2 inch to 3 inches thick. Return to service in 1 hour.
2. Repair Mortar System No. 2: Patches, joints, or overlays 1/2 inch to 3 inches thick. Return to service in 3 hours to 7 days.
3. Repair Mortar System No. 3: Patches, joints, or overlays 1 inch thick or greater. Return to service in 7 days or more.
4. Repair Mortar System No. 4: Heavy-duty joints or overlays 2 inches thick or greater. Return to service in 7 days or more.
5. Repair Mortar System No. 5: Patches and overlays 1/4 inch to 3 inches thick. Return to service for foot traffic in 4 hours; wheel traffic in 7 days.

B. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer. Review proposed extent of repair with Engineer.

C. Remove unsound, deteriorated, or otherwise defective areas of concrete from Work areas.

1. Use 8,000 psi minimum high-pressure water blasting machine, as appropriate to suit Site conditions.
2. Remove concrete to abrade substrate concrete surface to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. For existing structures, extent of concrete removal as shown on Drawings.
4. Where final surface is required to be flush with existing adjacent surface, remove existing concrete depth as required for application of minimum thickness of repair mortar.

D. Do not use power-driven jackhammers, chipping hammers, scabblers, or scarifiers unless water blasting is not permitted or practical because of

Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

E. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

F. Remove unsound concrete to satisfaction of Engineer.

G. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

H. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to entire circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

I. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

J. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

K. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System Nos. 1, 2, 3, and 5: Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer's printed instructions.

L. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System No. 4 Repair Mortar: Dry, in accordance with material manufacturer's printed instructions.

M. Spalled Joints:

1. Saw cut edge 1 inch deep and 6 inches back from old joint.
2. Remove unsound concrete and concrete between saw cut and joint.
3. Place wood or fiber spacer to thickness of joint at joint line.

N. Overlays:

1. Square cut edges to a minimum of 1/4 inch deep.
2. Do not feather edge area.
3. Perform special preparation recommended by mortar manufacturer.

O. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.03 REINFORCEMENT INSTALLATION

A. Provide steel reinforcement when existing steel reinforcement is not exposed and when mortar application is more than 4 inches deep, unless otherwise shown on Drawings.

B. Replace deteriorated steel reinforcement with new steel reinforcement equivalent in cross-sectional area to original steel reinforcement.

C. Install mesh anchors in accordance with mesh manufacturer's instructions.

D. Fasten steel reinforcement to chairs or mesh anchors with tie wire to prevent from moving during placement of repair mortar.

E. Lap reinforcement mesh a minimum of one mesh spacing and securely fasten mesh to mesh anchors, or to steel reinforcement fastened to mesh anchors, with tie wire at intervals no more than 12 inches to prevent movement during application of repair mortar.

F. Coat exposed new and existing steel reinforcement with cementitious reinforcement coating at the same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

3.04 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

3.05 PLACEMENT

A. Repair Mortar System Nos. 1, 2, 3, and 5:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.
7. Repair Mortar System No. 5 screed or use self-leveling mixture to obtain a uniform and plane surface.

B. Repair Mortar System No. 4:

1. Remove free water from prepared area.
2. Apply bonding agent to prepared surface in accordance with manufacturer's instructions. Do not apply more bonding agent than can be covered with mortar before bonding agent cures, past tacky to the touch.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.

C. Joint Repair:

1. Remove joint spacer when repair mortar is hard enough that a pointed trowel will penetrate surface less than 1/2 inch.
2. When repair mortar is cured and ready for use, fill joint in accordance with repair mortar system manufacturer's instructions.

3.06 FINISHING

A. Spray full strength evaporation retardant on fresh concrete to prevent rapid drying during hot and windy weather.

3.07 CURING

A. Repair Mortar System No. 1:

1. No curing is required.
2. Protect from rain immediately after placing.
3. Liquid-membrane curing compounds or plastic sheeting may be used in accordance with repair mortar manufacturer's instructions to protect the surface from precipitation.
4. Never wet cure.

B. Repair Mortar System Nos. 2, 3, 4, or 5: Apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.08 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Chain drag or light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete. Other methods approved by the Engineer may alternatively be used to identify improperly bonded areas.
2. Mark hollow areas for removal and replacement.

B. Remove and replace unacceptable Work.

3.09 MANUFACTURERS' SERVICES

A. Provide mortar manufacturer's representative at Site to advice on product selection, review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.10 CLEANING

A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

END OF SECTION

SECTION 03 10 00
CONCRETE FORMING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specification for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. 350.5, Specifications for Environmental Concrete Structures.
   d. 318, Building Code Requirements for Structural Concrete
   e. 350, Code Requirements for Environmental Engineering Concrete Structures.
2. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

1.02 DEFINITIONS

A. Architectural Concrete: See definition in Section 03 30 00, Cast-in-Place Concrete.

B. Defective Areas: See definition in Section 03 30 00, Cast-in-Place Concrete.

C. Exposed Concrete: See definition in Section 03 30 00, Cast-in-Place Concrete.

1.03 DESIGN REQUIREMENTS

A. Design formwork in accordance with ACI 301 and ACI 318 for cast-in-place concrete structures and ACI 350.5 and ACI 350 for cast-in-place that retain or exclude liquids to provide concrete finishes specified in Section 03 30 00, Cast-in-Place Concrete.

B. Unless otherwise specified, limit deflection of facing materials for concrete surfaces to comply with ACI 301. Limit deflection of facing materials to comply with tolerance limits established by Contract Documents and with tolerances required by equipment manufacturers. Coordinate tolerance requirements with equipment manufacturers.

C. Make joints in forms watertight.

D. When high range water reducer (superlasticizer) is used in concrete mix, forms shall be designed for full hydrostatic pressure per ACI 347.

E. Form liner and concrete mixtures shall be compatible. Coordinate compatibility between form liner manufacturer and concrete producer.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Formwork drawings signed and sealed by a licensed professional engineer in the State of Utah.
   b. Layout of panel joints, form liners, and tie hole pattern.
   c. Double-Wall Construction (new wall placed against an existing wall): Drawings and details of double-wall forming and premolded joint filler attachment; refer to details shown on Drawings.
2. Product Data:
   a. Form release agent.
   b. Form ties.
   c. Products to be used for sealing tie holes.
   d. Manufacturer's data for form liners where form liners are used on the Project.
3. Samples: One each as follows:
   a. Form ties.
   b. Form liners.

B. Informational Submittals:

1. Statement of qualifications for formwork designer.
2. Statement of qualifications for form liner designer.
3. Statement of qualifications for form liner installer.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Formwork Designer: Formwork, falsework, and shoring design shall be designed by an engineer licensed in the State of Utah.
2. Form liner designer shall have previous experience with design and installation of comparable form liners.
3. Form liner installer shall be approved by form liner manufacturer.

B. Mockup Panel: Construct as specified in Section 03 30 00, Cast-in-Place Concrete, for each form liner type.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect form liners from damage during delivery, storage, and handling.

B. Store form liners in accordance with manufacturer's written instructions.

PART 2 PRODUCTS

2.01 FORM MATERIALS

A. Wall Forms and Underside of Slabs and Beams:

1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in "new and undamaged" condition, of sufficient strength and surface smoothness to produce specified finish. When using form liners, use form material recommended by form liner manufacturer. Plywood may be of lower finish grade when used in conjunction with form liners.
2. Where steel forms or form liners are used, treat steel surfaces to prevent rusting using products approved for use on steel forms.
3. Circular Structure:
    a. Wall forms shall conform to circular shape of structure.
    b. Straight panels may be substituted for circular forms provided panels do not exceed 2 feet in horizontal width and angular deflection is no greater than 3-1/2 degrees per joint.

B. Column Forms:

1. Rectangular Columns: As specified for walls.
2. Circular Columns: Fabricated steel or fiber-reinforced plastic with bolted sections or spirally wound laminated fiber form. Internally treat with release agent for full height of column.

C. Form Liners:

1. Material: Elastomeric, FRP, ABS, or PVC.
2. Manufacturing Tolerance: Overall dimensions within 0.125 inch at time of manufacture.
3. Controlled Permeability Form Liner:
    a. Consists of filter fabric bonded to backing grid with documented ability to improve concrete surface.
    b. Properties:
        1) Maximum Pore Size: Less than 0.050 mm.
        2) Water Retention Capacity: 1.30 liters per square meter without drainage, minimum.
        3) Absorbency: 0.1 liter per square meter, maximum.
        4) Compression: Less than 10 percent under a pressure of 200 kPa.

5) Tensile Strength at 5 Percent Elongation: 8 kN/square meter, minimum.

c. Manufacturer and Product: Dupont; Zemdrain MD.

D. Sandblasted Surface Forms: Medium-density overlay plywood for flat concrete surfaces to be sandblasted.

E. Painted Surface Forms: High-density overlay plywood for flat concrete surfaces to be painted.

F. All Other Forms: Materials as specified for wall forms.

2.02 ACCESSORIES

A. Form Release Agent:

1. Material:
   a. Not to bond with, stain, or adversely affect concrete surfaces.
   b. Not to impair subsequent treatments of concrete surfaces when applied to forms or form liners.
   c. Ready-to-use water-based material formulated to reduce or eliminate surface imperfections.
   d. Contain no mineral oil or organic solvents.
   e. Certified for conformance to NSF 61 and use in potable water structures.

B. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Snap-Ties:

1. Material: Steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.
4. Flat bar ties for panel forms; furnish plastic or rubber inserts with minimum 1.5-inch depth and sufficient dimensions to permit patching of tie hole.

D. Form Snap-Ties with Water Stop:

1. For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
   a. Integral steel water stop 0.103-inch thick and 0.625-inch diameter tightly and continuously welded to tie.
   b. Neoprene water stop 3/16-inch thick and 15/16-inch diameter whose center hole is one-half diameter of tie, or molded plastic water stop of comparable size.
   c. Orient water stop perpendicular to tie and symmetrical about center of tie.
   d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

E. Through-Bolts:

1. At Contractor's option, may be used as alternate to form snap-tie or form snap-tie with water stop.
2. Tapered minimum 1-inch diameter at smallest end.
3. Elastic Vinyl Plug for Through-Bolt Tie Holes:
   a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal; forms watertight seal.

PART 3 EXECUTION

3.01 FORM SURFACE PREPARATION

A. Prior to coating surface, thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants.

B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by manufacturer.

C. Steel Forms: Apply form release agent as soon as they are cleaned to prevent discoloration of concrete from rust.

D. Form Liner Forms:

1. Prepare forms as recommended by manufacturer.
2. Provide liners in full sheets and locate seams as shown on approved Shop Drawings.
3. Anchor liners to formwork as recommended by liner manufacturer.
4. Clean form liner after each use and use only form release agents approved by form liner manufacturer.

3.02 ERECTION

A. General: In accordance with ACI 301, unless otherwise specified.

B. Beveled Edges (Chamfer):

1. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
2. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain Engineer's approval of size prior to placement of beveled edge.

C. Wall Forms:

1. Do not reuse forms with damaged surfaces.
2. Locate form ties and joints in uninterrupted uniform pattern.
3. Inspect form surfaces prior to installation to ensure conformance with specified tolerances.

D. Double-Wall Construction (new wall cast against existing wall):

1. Joint Filler Attachment:
   a. Use attachments to secure premolded joint filler to one wall only.
   b. Secure premolded joint filler without gaps and separations keeping concrete from second wall pour from penetrating thickness and space occupied by premolded joint filler.
2. Do not use form ties or other devices permanently penetrating premolded joint filler between walls or produce a rigid connection between walls.
3. First cast wall shall obtain the greater of the wall design concrete strength or the construction strength required, as determine by form design engineer, prior to casting second wall. Strength determination shall be based on field cast and cured test cylinders.
4. Do not use formwork that leaks mortar.
5. Provide premolded joint filler or sealant to minimize transfer of movement from one structure to the other.

E. Forms Supporting Form Liners:

1. Construct to structurally withstand deflection, movement, leakage, high hydraulic pressures resulting from rapid filling and heavy-high frequency vibration.
2. Lay out form joints and ties in uniform pattern, unless otherwise shown.

F. Form Liner Installation:

1. Protect form liners from extended exposure to sunlight and from high surface temperatures during installation.
2. Handle, cut, and install form liners in accordance with form liner manufacturer's instructions and recommendations.
3. Place form liners with level and square, unless otherwise noted and in accordance with specified patterns and joints.
4. Maintain required concrete cover between form liner and steel reinforcement.

G. Curb, Sidewalk, and Driveway Forms:

1. Provide standard steel or wood forms.
2. Set forms to true lines and grades, and securely stake in position.

H. Form Tolerances:

1. Provide forms in accordance with ACI 117 and ACI 318, and the following tolerances for finishes specified:
    a. See the Schedule of Concrete Finishes in Section 03 30 00, Cast-in-Place Concrete, for beam, column, and wall types related to required form tolerances.
    b. Wall Tolerances:
        1) Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
        2) Wall Type W-A:
            a) Plumb within 1/4 inch in 10 feet or within 1 inch from top to bottom for walls over 40 feet high.
            b) Depressions in Wall Surface: Maximum 5/16 inch when 10-foot straightedge is placed on high points in all directions.
        3) Wall Type W-B:
            a) Plumb within 1/8 inch in 10 feet or within 1/2 inch from top to bottom for walls over 40 feet high.
            b) Depressions in Wall Surface: Maximum 1/8 inch when 10-foot straightedge is placed on high points in all directions.
        4) Thickness: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
        5) Form Offset: Between adjacent pieces of formwork, facing material shall not exceed 1/8 inch for architectural concrete, otherwise 1/4 inch.
    c. Beams and Columns Tolerances:
        1) Exposed Straight Horizontal and Vertical Surfaces: Flat planes within tolerances specified.

2) Lateral Alignment:
   a) Centerlines shall be within plus or minus 1/2 inch from dimensions shown.
   b) At intersections, centerlines shall intersect within plus or minus 1/2 inch of dimensions shown.
3) Beam Type B-A:
   a) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
   b) Elevations: Within plus or minus 1/2 inch, except where tops of beams become part of finished slab. In this case, refer to slab tolerances.
4) Column Type C-A:
   a) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
   b) Plumb within 1/4 inch in 10 feet in all directions with maximum 1/2 inch out-of-plumb at top with respect to bottom.

3.03 FORM REMOVAL

A. Nonsupporting forms, sides of beams, walls, columns, and similar parts of Work, may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:

   1. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
   2. Curing and protection operations are maintained.

B. Elevated Structural Slabs or Beams: In accordance with ACI 318, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28-day compressive strength as determined by test cylinders.

C. Forms with Form Liners: Remove formwork in accordance with form liner manufacturer's recommendations. Use consistent form liner removal timing to avoid variations in concrete color. Avoid damaging formed profiles.

D. Form Ties: Remove conical inserts or through bolts and plug holes as specified in Section 03 30 00, Cast-in-Place Concrete.

3.04 MANUFACTURER'S SERVICES

A. Provide form liner manufacturer's representative at Site for installation assistance, and inspection.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

B. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 03 15 00
CONCRETE JOINTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A36/A36M, Specification for Carbon Structural Steel.
   b. A615/A615M, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   d. A767/A767M, Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
   e. C920, Specification for Elastomeric Joint Sealants.
   f. D226, Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
   g. D227, Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
   h. D994, Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
   i. D1056, Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
   j. D1171, Standard Guide for Evaluating Nonwoven Fabrics.
   k. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   l. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   m. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
2. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.
3. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Waterstop: Details of splices, method of securing and supporting waterstop in forms to maintain proper orientation and location during concrete placement.
   b. Construction Joints, Expansion Joints and Control Joints: Layout and location for each type. Include joint locations shown on Drawings, additional required joint locations and any proposed alternate locations.
2. Product Data:
   a. Waterstops.
   b. Bond breaker.
   c. Premolded joint fillers.
   d. Pourable joint fillers.
   e. Preformed control joints.
   f. Epoxy-coated dowels.
   g. Roofing felt.
   h. Accessories not specified in other sections.
3. Samples: PVC waterstop splice, joint, and fabricated cross of each size, shape, and fitting of waterstop.

B. Informational Submittals:

1. Certification:
   a. Joint Filler(s) for Potable Water Structures: Confirmation material is certified to meet requirements of NSF 61.
   b. Manufacturer's application instructions for:
      1) Bonding agent.
      2) Bond breaker.
2. Manufacturer's written instructions for product shipment, storage, handling, installation/application, and repair for:
   a. Waterstops.
   b. Bond breaker.
   c. Bonding agent.
   d. Premolded joint fillers.
   e. Pourable joint fillers (sealant proportions not required as products used only as a filler).
   f. Preformed control joints.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site: Verify delivered materials are in accordance with Specifications, regulatory agencies, and Manufacturer's product data sheets prior to unloading and storing onsite.

B. Storage: Store materials under tarps to protect from oil, dirt, and sunlight or as required by Manufacturer.

PART 2 PRODUCTS

2.01 PLASTIC WATERSTOP

A. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.

B. Specific Gravity: Approximately 1.37.

C. Shore Durometer Type A Hardness: Approximately 80.

D. Performance Requirements: COE Specification CRD-C-572.

E. Type Required in All Expansion, Contraction, and Control Joints: 6 inches wide or 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center, as indicated on Drawings.

F. Type Required in Construction Joints: Flat ribbed, 6 inches wide or 9 inches wide with parallel longitudinal ribs or protrusions on each side of strip center. Center bulb is optional.

G. Corrugated or tapered type waterstops are not acceptable.

H. Thickness: Constant from bulb edge (or center of waterstop) to outside stop edge.

I. Minimum Weight per Foot of Waterstop:

1. 0.50 pound for 3/16 inch by 4 inches.
2. 1.60 pounds for 3/8 inch by 6 inches.
3. 2.30 pounds for 3/8 inch by 9 inches.

J. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.

K. Manufacturers and Products for Center Bulb Type:

1. Use same manufacturers for flat ribbed profile:
   a. Vinylex Corp., St Louis, MO; No. RB638H (6 inches by 3/8 inch) and No. RB938H (9 inches by 3/8 inch).
   b. Greenstreak, St. Louis, MO; Style No. 702 (4 inches by 3/16 inch), Style 732 (6 inches by 3/8 inch), and Style 735 (9 inches by 3/8 inch).
   c. Durajoint, Garrettsville, OH; Type 3 (4 inches by 3/16 inch), Type 9 (6 inches by 3/8 inch), and Type 10 (9 inches by 3/8 inch).
   d. BoMetals, Carrollton, GA: No. RCB-4316LB (4 inches by 3/16 inch), No. RCB-638LB (6 inches by 3/8 inch) and No. RCB-938NT (9 inches by 3/8 inch).
   e. Dacon Plastics LLC, Jacksonville, TX; No. RCB11 (4 inches by 3/16 inch), No. RCB17 (6 inches by 3/8 inch), and No. RCB18 (9 inches by 3/8 inch).

2.02 WIRE LOOPED PLASTIC WATERSTOP

A. Furnish as alternative to plastic waterstops.

B. Same material and geometry as plastic waterstops.

C. Furnish with continuous galvanized wire looping at edge for convenience in positioning and securing stop in place in forms.

D. Manufacturer and Product: Paul Murphy Plastics, Roseville, MI; “Wire Stop Waterstop”; geometry numbers ACR 6380, ACR 9380, as shown on Paul Murphy Plastics Co., Drawing No. CCP-120-12M.

2.03 HYDROPHILIC WATERSTOP

A. For use at construction joints only, where new concrete is placed against existing concrete and as shown on Drawings.

B. Material shall be a nonbentonite hydrophilic rubber compound.

C. Manufacturers and Products:

1. Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
2. Adeka Ultra Seal, JLM Associates, Spearfish, SD; MC-2010M with 3M-2141 adhesive and P-201 sealant.

2.04 BOND BREAKER

A. Tape for Joints: Adhesive-backed glazed butyl or polyethylene tape. Same width as joint that will adhere to premolded joint material or concrete surface.

B. Use bond prevention material as specified in Section 03 30 00, Cast-in-Place Concrete, except where bond breaker tape is specifically called for on Drawings.

2.05 PREMOLDED JOINT FILLER

A. Bituminous Type: ASTM D994 or ASTM D1751.

B. Sponge Rubber:

1. Neoprene, closed-cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 kPa to 168 kPa (17 psi to 24 psi) minimum. Use in joints for potable and nonpotable water containment structures.
2. Manufacturer and Product: Monmouth Rubber and Plastics, Corp, Long Branch, NJ; Durafoam DK5151.

2.06 POURABLE JOINT FILLERS

A. General:

1. Although product is a sealant, it is being specified as a filler to prevent debris accumulation and allow expansion and contraction under shrinkage and thermal loads. It does not need to meet proportional sealant geometry requirements.
2. For Potable Water Containment structures, meet requirements of NSF 61.

B. Filler for Potable or Non-Potable Water Containment Structures:

1. Multicomponent sealant, self-leveling or nonsag as required for level, sloping, or vertical joints.
2. Color: White, unless approved or directed otherwise by the Engineer.
3. Manufacturer and Product: Sika Corp., Lyndhurst, NJ; Sikaflex-2c SL.

C. Filler for Nonpotable Water Containment Structures Only:

1. Pourable, two-component, cold-applied compound meeting ASTM C920, Type M, Grade P, Class 25, Use T.
2. Color: Black, unless approved or directed otherwise by the Engineer.
3. Manufacturer and Product: W.R. Meadows, Inc., Elgin, IL; Gardox.

2.07 STEEL EXPANSION JOINT DOWELS

A. Dowels: ASTM A36/A36M round smooth steel bars.

B. Bar Coating: As specified in Section 09 90 00, Painting and Coating, with factory-applied epoxy coating and factory or field applied lubrication coating.

2.08 ACCESSORIES

A. Joint Sealant: Polyurethane as specified in Section 07 92 00, Joint Sealants.

B. Roofing Felt: ASTM D226, Type II, 30-pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.

C. Steel Reinforcement: As specified in Section 03 21 00, Steel Reinforcement.

D. Nails: Galvanized, as required for securing premolded joint filler.

E. Galvanized Rebar at Control Joints: ASTM A767/A767M and ASTM A615/A615M Grade 60 prior to galvanizing.

F. Ties for PVC Waterstop: “Hog Rings” or grommets for each edge at 12-inch maximum spacing.

PART 3 EXECUTION

3.01 GENERAL

A. Commence concrete placement after joint preparation is complete.

B. Time Between Concrete Pours: As specified in Section 03 30 00, Cast-in-Place Concrete.

3.02 SURFACE PREPARATION

A. Construction Joints: Prior to placement of abutting concrete, clean contact surface.

1. Remove laitance and spillage from steel reinforcement and dowels.
2. Roughen surface to minimum of 1/4-inch amplitude:
   a. Sandblast after concrete has fully cured.
   b. Water blast after concrete has partially cured.
   c. Green cut fresh concrete with high-pressure water and hand tools.
3. Perform cleaning so as not to damage waterstop, if one is present.

B. Expansion Joint:

1. Use wire brush or motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic waterstop to top of joint.
2. Use dry, high-pressure air to remove dust and foreign material, and dry joint.
3. Prime surfaces as required before placing joint filler.
4. Avoid damage to waterstop.

C. Contraction Joint and Control Joint:

1. Coat concrete surfaces above and below plastic waterstop with bond breaker.
2. Do not damage or coat waterstop.

D. Construction Joint with Hydrophilic Waterstop:

1. Follow hydrophilic waterstop manufacturer's written instructions.
2. Clean debris, dirt, dust, and foreign material from concrete surface. Concrete surface must be smooth, clean, and dry. Grind concrete as required.

3.03 INSTALLATION OF WATERSTOPS

A. General:

1. Continuous waterstop shall be installed in all construction joints of water holding basins and belowgrade structures, unless specifically noted otherwise.
2. Join waterstop at intersections to provide continuous seal.
3. Center waterstop on joint.

4. Secure waterstop in correct position. Tie waterstop to steel reinforcement using grommets, “Hog Rings,” or tiewire at maximum spacing of 12 inches. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.
7. Joints in Footings and Slabs:
    a. Ensure that space beneath horizontal waterstop is completely filled with concrete.
    b. During concrete placement, make visual inspection of waterstop area.
    c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift ribbed waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.

B. Plastic Waterstops:

1. Install in accordance with manufacturer’s written instructions.
2. Splice in accordance with waterstop manufacturer’s written instructions using Teflon-coated thermostatically controlled heating iron at approximately 380 degrees F.
    a. Allow at least 10 minutes before new splice is pulled or strained in any way.
    b. Finished splices shall provide cross-section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
    c. Use only factory made waterstop fabrications for all intersections, changes of directions and transitions.
    d. Field splice permitted only for straight butt welds.
3. Wire looped plastic waterstop may be substituted for plastic waterstop.

C. Hydrophilic Waterstop:

1. Install in accordance with manufacturer’s written instructions.
2. Provide minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of steel reinforcement, locate centered between layers of steel or as shown.
3. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
4. Lap ends of waterstop strip together at splices and corners and join with sealant.

5. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.
6. Lap hydrophilic waterstop 2 feet minimum with intersecting plastic waterstops.

3.04 EXPANSION JOINT INSTALLATION

A. Premolded Joint Filler:

1. Sufficient in width to completely fill joint space where shown.
2. Install per manufacturer's written instructions.
3. If waterstop is in joint, cut premolded joint filler to butt tightly against waterstop and concrete face.
4. Precut premolded joint filler to required depth at locations where joint filler or sealant is to be applied.
5. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately shaped material. Entire joint above waterstop, in slabs, shall be formed and removed so that entire space down to waterstop can be filled with the pourable joint filler.
6. Vibrate concrete thoroughly along joint form to produce dense, smooth surface.

B. Bituminous Type Premolded Joint Filler:

1. Drive nails approximately 1 foot 6 inches on center through filler, prior to installing, to provide anchorage embedment into concrete during concrete placement.
2. Secure premolded joint filler in forms before concrete is placed.
3. Install in walkways, at changes in direction, at intersections, at each side of driveway entrances, and at 45-foot intervals, maximum.

C. Sponge Rubber Joint Filler: Install per manufacturer's written instructions.

D. Pourable Joint Filler:

1. General:
   a. Install in accordance with the manufacturer's written instructions, except as specified below:
      1) Apply primer prior to pouring joint filler.
      2) Fill entire joint above the waterstop with joint filler as shown.
      3) Use masking tape on top of slabs at sides of joints; clean spillage. Remove masking tape afterwards.
      4) Sealant products used as fillers need not meet sealant geometry parameters. Do not use backing rods.

E. Steel Expansion Joint Dowels:

1. Install coated and lubricated bars parallel to wall or slab surface and in true horizontal position perpendicular to joint in both plan and section view, so as to permit joint to expand or contract without bending dowels.
2. Secure dowels tightly in forms with rigid ties.
3. Install steel reinforcement in concrete as shown.

3.05 CONTRACTION JOINT INSTALLATION

A. Place bond breaker above and below waterstop.

B. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.

3.06 CONTROL JOINT INSTALLATION

A. Locate steel reinforcement as shown.

B. Install waterstop.

C. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.

D. Install bond breaker to concrete surfaces above and below waterstop.

3.07 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

3.08 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

B. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 03 21 00
STEEL REINFORCEMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specification for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. SP-66, Detailing Manual.
2. American Welding Society (AWS): D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
3. ASTM International (ASTM):
   a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   b. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   c. A767/767M, Standard Specification for Zinc-Coated (Galvanized) Steel bars for Concrete Reinforcement.
   d. A775/A775M, Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
   e. A1064/A1064M, Standard Specification for Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
4. Concrete Reinforcing Steel Institute (CRSI):
   a. Placing Reinforcing Bars.
   b. Manual of Standard Practice.
5. International Code Council (ICC): Evaluation Services Report.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings prepared in accordance with ACI 301 and ACI SP-66:
   a. Bending lists.
   b. Placing drawings.
2. Welded, metallic sleeve splice, and mechanical threaded connection.

B. Informational Submittals:

1. Lab test reports for steel reinforcement showing stress-strain curves and ultimate strengths.
2. Mechanical Threaded Connections:
   a. Current ICC Evaluation Services Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
   b. Verification device threads have been tested and meet requirements for thread quality, in accordance with manufacturer's published methods.
   c. Manufacturer's instructions.
3. Epoxy-coated Reinforcing Bars: Written certification in accordance with Paragraph 14.1 of ASTM A775/A775M.
4. Welding Qualification: Prior to welding, submit welder qualifications and nondestructive testing procedures in accordance with AWS D1.4 Structural Welding Code - Reinforcing Steel.
5. Test results of field testing.

1.03 QUALITY ASSURANCE

A. Welder Qualifications: Certified in accordance with AWS D1.4/D1.4M.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with ACI 301 and recommendations of CRSI Placing Reinforcing Bars.

B. Epoxy-coated Reinforcing Bars:

1. Protect contact areas of epoxy-coated bars from handling equipment.
2. Lift bundles of bars at multiple pickup points to minimize bar-to-bar abrasion from sags in bundles.
3. Do not drop or drag bars or bundles of bars.
4. Store bars on protective cribbing.
5. Color fading of coating is not cause for rejection of epoxy-coated reinforcing bars.

PART 2 PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars:

1. Includes stirrups, ties, and spirals.
2. ASTM A615/A615M, Grade 60, typical unless noted otherwise.
3. ASTM A706/A706M, Grade 60, for reinforcing to be welded.

4. ASTM A767/767M, Grade 60, for galvanized bars.
5. ASTM A775/A775M, Grade 60 for epoxy-coated bars.

B. Mechanical Splices and Connections:

1. Metal Sleeve Splice:
   a. Furnish with cast filler metal, capable of developing, in tension or compression, 125 percent of minimum tensile strength of bar.
   b. Manufacturer and Product: Erico Products, Inc., Cleveland, OH; Cadweld T-Series.
2. Mechanical Threaded Connections:
   a. Furnish metal coupling sleeve with internal threads engaging threaded ends of bars developing in tension or compression 125 percent of yield strength of bar.
   b. Manufacturers and Products:
      1) Erico Products, Inc., Cleveland, OH; Lenton Reinforcing Steel Couplers.
      2) Erico Products, Inc., Cleveland, OH; Lenton Lock Mechanical Rebar Splicing System.
      3) Richmond Screw Anchor Co., Inc., Fort Worth, TX; Richmond DB-SAE Dowel Bar Splicers.

C. Welded Wire Fabric (Welded Wire Reinforcement):

1. ASTM A1064, using wire of 75 ksi minimum tensile strength.
2. Furnish flat sheets only, rolled sheets not permitted.

2.02 ACCESSORIES

A. Tie Wire:

1. Black, soft-annealed 16-gauge wire.
2. Nylon-coated, epoxy-coated, or plastic-coated wire.

B. Bar Supports and Spacers:

1. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.
2. Use only precast concrete bar supports and side form spacers where concrete surfaces are exposed to weather, earth, water, chloride intrusion, or corrosive chemicals. Bar supports shall be nonconductive and have geometry and bond characteristics that deter movement of moisture from the surface to the reinforcement.

3. Plastic bar supports may be used in interior spaces protected from exposure to weather, earth, water, chloride intrusion, or corrosive chemical and where approved by the Engineer.
4. Precast concrete supports shall have same minimum strength and shall be made from same materials as that of the concrete in which they are to be embedded. Precast concrete supports shall be cast and properly cured for at least 7 days before use and shall have a wire or other device cast into each block for the purpose of attaching them securely to steel reinforcement.
5. In Beams, Columns, Walls, and Slabs Exposed to View after Form Removal: Use small precast concrete blocks made of same color as concrete in which they are embedded. All-plastic bar supports and side form spacers may be used, except where surface is not protected from exposure as described above and also where not approved by Engineer.
6. Design and fabricate special bar supports for top reinforcing bars in slabs where standard bar supports do not possess necessary geometry, strength, or stiffness.
7. Use supports made of dielectric materials for epoxy-coated reinforcing bars supported from formwork.
8. If epoxy-coated reinforcing is used, furnish epoxy-coated reinforcing bars for spreader bars.
9. Precast Concrete Supports: Total bond precast, high-performance concrete bar supports as supplied by Dayton Superior, Miamisburg, OH; Dobies.
10. Plastic Bar Supports: Manufactured by Aztec Concrete Accessories, Bloomington, CA.

2.03 FABRICATION

A. Follow CRSI Manual of Standard Practice.

B. Bend bars cold.

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.

B. Clean reinforcing bars of loose mill scale, oil, earth, and other contaminants.

C. Repair damaged epoxy coating in accordance with ASTM A775/A775M and manufacturer's recommendations.

D. Coat wire projecting from precast concrete bar supports with dielectric material, epoxy, or plastic.

3.02 INSTALLATION

A. Bundle or space bars, instead of field bending where construction access through reinforcing is necessary.

B. Splicing:

1. Minimum length of lap splices shall comply with splice table in General Structural Notes on Drawings.
2. Use lap splices, unless otherwise shown or permitted in writing by Engineer.
3. Welded Splices:
   a. Not permitted unless expressly shown on the Drawings or with written approval from the Engineer.
   b. Accomplish by full penetration groove welds and develop a minimum of 125 percent of yield strength of bar.
4. Stagger splices in adjacent bars where indicated.

C. Mechanical Splices and Connections:

1. Use only in areas specifically approved in writing by Engineer.
2. Install threaded rods as recommended by manufacturer with threads totally engaged into coupling sleeve and in accordance with ICC Evaluation Services Report or equivalent code agency report.
3. For metal sleeve splice, follow manufacturer's installation recommendations.
4. Maintain minimum edge distance and concrete cover.

D. Tying Reinforcing Bars:

1. Tie every other intersection on mats made up of Nos. 3, 4, 5, and 6 bars to hold them firmly at required spacing.
2. Bend tie wire away from concrete surface to provide clearance of 1 inch from surface of concrete to tie wire.
3. Epoxy-coated Reinforcing Bars:
   a. Use epoxy-coated or nonmetallic clips.
   b. Repair coating damage at clipped or welded intersections.

E. Reinforcement Around Openings: On each side and above and below pipe or opening, place an equivalent area of steel bars to replace steel bars cut for opening. Extend steel reinforcing a standard lap length beyond opening at each end. See Drawings for additional requirements.

F. Welding Reinforcement:

1. Weld reinforcement only where shown on the Drawings or with written approval from the Engineer.
2. Only ASTM A706/A706M bars may be welded.
3. Do not perform welding until welder qualifications are approved.

G. Straightening and Rebending: Field bending of steel reinforcement bars is not permitted.

H. Unless permitted by Engineer, do not cut reinforcing bars in field. When epoxy-coated reinforcing bars are cut in field, coat ends of bars with same material specified for repair of epoxy coating damage.

3.03 WELDED WIRE FABRIC INSTALLATION

A. Use only where specifically shown.

B. Extend fabric to within 2 inches of edges of slab and lap splices at least 1-1/2 courses of fabric or minimum 8 inches.

C. Tie laps and splices securely at ends and at least every 24 inches with tie wire.

D. Place welded wire fabric on concrete blocks and rigidly support equal to that provided for reinforced bars. Do not use broken concrete, brick, or stone.

E. Do not use fabric that has been rolled. Install flat sheets only.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

B. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 03 24 00
FIBROUS REINFORCING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C78, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   b. C1116, Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
   c. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.

1.02 DEFINITIONS

A. Aspect Ratio: The ratio of length to diameter of the fiber.

B. Fibrillated Fibers: Fibers in bundles that, when added to concrete during mixing, separate into uniformly distributed angular fibrils (fiber strands) which act as secondary concrete reinforcement.

C. Macro-Fibers: Longer length, higher volume, typically 0.4 percent to 0.7 percent by volume fiber, sometimes referred to as structural fibers.

D. Micro-Fibers: Shorter length, low dose, typically 0.1 percent by volume fibers designed to control plastic shrinkage cracking.

E. Monofilament Fiber: Single filament fiber.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Minimum residual strength index of 50 psi.
2. 2-hour fire resistance rating when tested under ASTM E119 on Series 700, Series 800, and Series 900 composite metal deck assemblies.

1.04 SUBMITTALS

A. Action Submittals: Product data for fibrillated fibers.

B. Informational Submittals:

1. Manufacturer's written instructions for mixing and batching of fibrillated fibers.
2. Fiber manufacturer's Certificate of Compliance.
3. Manufacturer's written test procedure for the residual strength index of fiber reinforced concrete.
4. Fiber manufacturer's certification of registration as proof of ISO 9002 Fiber Manufacturing Facility Certification.

PART 2 PRODUCTS

2.01 MATERIALS

A. Micro-Fibers:

1. 100 percent virgin polypropylene self-fibrillating fibers.
2. Multidesign gradation.
3. Fibrillated bundles to allow uniform distributed angular fibrils (fiber strands) when mixed into concrete.
4. Specific Gravity: 0.91 minimum.
5. Reprocessed olefin materials are not allowed.
6. Type III fibers conforming to ASTM C1116, Part 4.1.3.
7. Fiber Length: 0.50 inch to 1.0 inch.
8. Manufacturers and Products:
    a. Euclid Chemical Company, Cleveland OH; PSI Fiberstrand F.
    b. GCP Applied Technologies, Inc, Cambridge, MA; SINTA F19.
    c. Sika Fibers LLC, Chattanooga, TN; Fibermesh 300-e3.

B. Macro-Fibers:

1. Polypropylene/polyethylene monofilament.
2. Specific Gravity: 0.92.
3. Tensile Strength: 85 ksi minimum.
4. Type III fibers conforming to ASTM C1116.
5. Aspect Ratio: 70 minimum.
6. Fiber Length: 1.50 inch to 2.0 inch.
7. Manufacturer:
    a. Euclid Chemical Company, Cleveland, OH; Tuf-Strand SF.
    b. GCP Applied Technologies, Inc, Cambridge, MA; Strux 90/40.
    c. Sika Fibers, LLC, Chattanooga, TN; Fibermesh 650-e3.

C. Concrete: Components shall conform to Section 03 30 00, Cast-in-Place Concrete.

2.02 CONCRETE MIX DESIGN AND CONCRETE MIXING

A. In accordance with Section 03 30 00, Cast-in-Place Concrete.

B. Mix fibers into concrete in accordance with fiber manufacturer's instructions.

PART 3 EXECUTION

3.01 PLACING, PROTECTING, CURING, AND FINISHING

A. In accordance with Section 03 30 00, Cast-in-Place Concrete.

3.02 FIELD QUALITY CONTROL

A. Test as specified in Section 03 30 00, Cast-in-Place Concrete.

B. Test fiber reinforced concrete with a modified version of ASTM C78 test using the printed test procedure provided by Fibermesh.

C. Test minimum of two beam Samples prior to casting the concrete.

D. Test minimum of two additional beam Samples for each 25 cubic yards or any portion thereof used on the Project.

3.03 MANUFACTURER'S SERVICE

A. Provide the services of a technical representative to instruct the concrete supplier in proper batching and mixing of materials.

END OF SECTION

SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specification for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. 305.1, Specification for Hot Weather Concreting.
   d. 306.1, Standard Specification for Cold Weather Concreting.
   e. 350.1, Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures.
   f. CP-1, Technical Workbook for ACI Certification of Concrete Field Testing Technician – Grade 1.
2. ASTM International (ASTM):
   a. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   b. C33/C33M, Standard Specification for Concrete Aggregates.
   c. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or Cube Specimens).
   f. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   g. C150/C150M, Standard Specification for Portland Cement.
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
   j. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   k. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
   l. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
   m. C595/C595M, Standard Specification for Blended Hydraulic Cements.
   n. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

o. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
p. C979/C979M, Standard Specification for Pigments for Integrally Colored Concrete.
q. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
r. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
s. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
t. C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method.
u. C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
v. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
w. C1240, Standard Specification for Silica Fume Used in Cementitious Mixtures.
x. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
y. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
z. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
aa. C1582/C1582M, Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete.
bb. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
cc. D4580, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding.
dd. E329, Standard Specification for Agencies Engaged in Construction Inspection, Special Inspection, or Testing Materials Used in Construction.
ee. E1155, Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers.

3. National Ready Mixed Concrete Association (NRMCA).

1.02 DEFINITIONS

A. Architectural Concrete: Concrete indicated as such in Contract Documents. Requires specified care in selection of concrete materials, forming, placing, and finishing in order to obtain desired architectural appearance.

B. Cementitious Crystalline Waterproofing: Concrete mix admixture that chemically controls and permanently fixes a nonsoluble crystalline structure throughout the capillary voids of the concrete.

C. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

D. Contractor's Licensed Design Engineer: Individual representing Contractor who is licensed to practice engineering as defined by statutory requirements of professional licensing laws in state or jurisdiction in which Project is to be constructed.

E. Defective Area: Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4 inch in diameter, cracks in liquid containment structures and below grade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.

F. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.

G. Hot Weather: As defined in ACI 305.1.

H. Hydraulic Structure: Structures which contain or convey liquid, or accessible spaces of below grade structures.

I. New Concrete: Less than 60 days old.

1.03 CEMENTITIOUS CRYSTALLINE WATERPROOFING PERFORMANCE REQUIREMENTS

A. Testing Requirements: Crystalline waterproofing system shall be tested in accordance with the following standards and conditions, and the testing results shall meet or exceed the performance requirements specified herein.

1. Independent Laboratory: Testing shall be performed by an independent laboratory meeting the requirements of ASTM E329 and certified by the United States Bureaus of Standards. Testing laboratory shall obtain all concrete samples and waterproofing product samples.

2. Crystalline Penetration: Crystallizing capability of waterproofing material shall be evidenced by independent SEM (Scanning Electron Microscope) photographs documenting penetration of crystal-forming waterproofing material to a minimum depth of 2 inches.
3. Permeability: Independent testing shall be performed according to U.S. Army Corps of Engineer s CRD C48-73 “Permeability of Concrete.”
    a. Concrete samples (treated and untreated) to have design strength of 2,000 psi and thickness of 2 inches. No other admixtures permitted.
    b. Samples shall be pressure tested to 175 psi (405 feet head of water).
    c. Treated samples, after crystalline growth has occurred, shall exhibit no measurable leakage.

B. Potable Water Approval: Independent testing shall be performed according to NSF Standard 61, and approval for use of waterproofing material on structures holding potable water shall be evidenced by NSF certification.

1.04 SUBMITTALS

A. Action Submittals:

1. Mix Designs:
    a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.
    b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
    c. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
        1) Portland cement.
        2) Fly ash.
        3) Slag cement.
        4) Aggregates, including specified class designation for coarse aggregate.
        5) Admixtures.
        6) Concrete producer has verified compatibility of constituent materials in design mix.

d. Test Reports:
   1) Cement: Chemical analysis report.
   2) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
   3) Certified complete test reports form independent testing laboratory certifying that cementitious crystalline waterproofing conforms to performance characteristics and testing requirements specified herein.
   4) Water-Soluble Chloride-Ion Content in Hardened Concrete: Unless otherwise permitted, in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
   5) Shrinkage Test Results: In accordance with ASTM C157/C157M as modified herein.

e. Aggregates:
   1) Coarse Aggregate Gradation: List gradings and percent passing through each sieve with testing performed within 12 months prior to submittal.
   2) Fine Aggregate Gradation: List gradings and percent passing through each sieve with testing performed within 12 months prior to submittal.
   3) Combined gradation for coarse and fine aggregates. List gradings and percent passing through each sieve.
   4) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 2.
   5) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 4.
   6) Test Reports:
      a) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete Mix Design. Include documentation of test results per applicable standards.

f. Admixtures: Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.

2. Product Data: Specified ancillary materials.
3. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details shall include, but not be limited to, the following:
   a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
   b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   c. Methods for temperature protection during placement.

d. Types of covering, insulation, housing, or heating to be provided.
e. Curing methods to be used during and following protection period.
f. Use of strength accelerating admixtures.
g. Methods for verification of in-place strength.
h. Procedures for measuring and recording concrete temperatures.
i. Procedures for preventing drying during dry, windy conditions.

4. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan shall include, but not be limited to, the following:
   a. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   b. Use of retarding admixture.
   c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
   d. Types of shading and wind protection to be provided.
   e. Curing methods, including use of evaporation retardant.
   f. Procedures for measuring and recording concrete temperatures.
   g. Procedures for preventing drying during dry, windy conditions.
5. Thermal Control Plan: For concrete sections with a minimum specified thickness that is greater than 2 feet 6 inches.

B. Informational Submittals:

1. Preinstallation Conference minutes.
2. Manufacturer's application instructions for bonding agent, bond breaker, and cementitious crystalline waterproofing.
3. Manufacturer's Certificate of Compliance to specified standards and the requirements of this Specification:
   a. Bonding agent.
   b. Bond breaker.
   c. Cementitious crystalline waterproofing.
4. Statement of Qualification:
   a. Batch Plant: Certification as specified herein.
   b. Applicator qualification and approval for cementitious crystalline waterproofing installation from manufacturer.
   c. Mix designer.
   d. Installer.
   e. Testing agency.
5. Field test reports.

6. Field test report for proper application of cementitious crystalline waterproofing for manufacturer's representative.
7. Recorded temperature data from concrete placement where specified.
8. Tightness test results.
9. Concrete Delivery Tickets:
    a. For each batch of concrete before unloading at Site.
    b. In accordance with ASTM C94/C94M, including requirements 14.2.1 through 14.2.10.
    c. Indicate amount of mixing water withheld and maximum amount that may be permitted to be added at Site.

1.05 QUALITY ASSURANCE

A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.

B. Cementitious Crystalline Waterproofing: Provide products of manufacturer with no less than 5 years of experience in manufacturing the cementitious crystalline waterproofing material for the required work.

C. Qualifications:

1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of the Work. Requirement may be waived if individual is Contractor's Licensed Design Engineer.
3. Flatwork Finisher: Unless otherwise permitted, at least one person on finishing crew shall be certified as an ACI Flatwork Finisher or equivalent.
4. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
    a. Where field testing is required of Contractor, personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
    b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Thermal Control Plan:

1. When required, shall include the following minimum requirements:
   a. Calculated or measured adiabatic temperature rise of concrete.
   b. Upper limit for concrete temperature at time of placement.
   c. Description of specific measures and equipment that will be used to ensure maximum temperature in placement will not exceed specified maximum temperature limit.
   d. Calculated maximum temperature in placement based on expected conditions at time of placement and use of proposed measures to control temperatures.
   e. Description of specific measures and equipment that will be used to ensure temperature difference will not exceed specified temperature difference limit.
   f. Calculated maximum temperature difference in placement based on expected conditions at time of placement and use of proposed measures to control temperature differences.
   g. Description of equipment and procedures that will be used to monitor and log temperatures and temperature differences.
   h. Drawing showing locations for temperature sensors in placement.
   i. Description of format and frequency of providing temperature data to Engineer.
   j. Description of measures to address and reduce excessive temperatures and temperature differences, if they occur.
   k. Description of curing procedures, including materials and methods, and curing duration.
   l. Description of formwork removal procedures to ensure temperature difference at temporarily exposed surface will not exceed temperature difference limit, and how curing will be maintained.
   m. Alternate temperature limits when permitted by Engineer.
      1) Determination of alternate temperature limits shall be based on detailed thermal and crack analyses.
      2) Analyses shall be stamped by Contractor's Licensed Design Engineer.
   n. If concrete design mixture is changed, thermal control plan must be updated.

E. Mockup Panels:

1. Construct one panel for each form liner type specified in Section 03 10 00, Concrete Forming and Accessories.

2. Construct in accordance with requirements of Contract Documents to demonstrate wall finish Type W-7 and W-9.
   a. Dimensions: 10 feet by 8 feet, minimum or as approved by Engineer.
3. Before concrete work starts, construct panels with specified materials, forming systems, reinforcing details, and leakage prevention techniques.
4. Show architectural details, joints, form ties, form liners, and rebar spacers to produce finished surface required.
5. Test form release agent on one mockup panel to ensure no adverse effects are caused on form or form liner materials.
6. Surface finish and color shall be uniform in appearance to Samples.
7. Approved panels shall establish standards of quality by which Work will be judged.
8. Replace panels if not representative of Work as specified.
9. Panels may be incorporated into Work if approved by Engineer.

F. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Contractor, including pumping, placing and finishing, and curing subcontractors.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.
   e. Engineer.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
   a. Admixture types, dosage, performance, and redosing at Site.
   b. Mix designs, test of mixes, and Submittals.
   c. Placement methods, techniques, equipment, consolidation, and form pressures.
   d. Slump and placement time to maintain slump.
   e. Finish, curing, and water retention.
   f. Thermal control plan.
   g. Protection procedures for weather conditions.
   h. Other specified requirements requiring coordination.
4. Conference minutes as specified in Section 01 31 19, Project Meetings.

1.06 WARRANTY

A. Cementitious crystalline waterproofing Manufacturer's Warranty: Manufacturer shall provide standard product warranty executed by authorized company official. Term of warranty shall be 5 years form Date of Substantial Completion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cementitious Materials:

1. Cement:
   a. Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
   b. Furnish from one source.
2. Supplementary Cementitious Materials (SCM):
   a. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
      1) ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.

B. Aggregates: Furnish from one source for each aggregate type used in a mix design.

1. Normal-Weight Aggregates:
   a. In accordance with ASTM C33/C33M, except as modified herein.
      1) Class Designation: 4S, unless otherwise specified.
   b. Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
   c. Obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by submitted historical data or used in trial mixtures.
   d. Alkali Silica Reactivity: See Article Concrete Mix Design.
2. Fine Aggregates:
   a. Clean, sharp, natural sand.
   b. ASTM C33/C33M.
   c. Limit deleterious substances in accordance with ASTM C33/C33M, Table 2 and as follows:
      1) Limit material finer than 75-μm (No. 200) sieve to 3 percent mass of total sample.
      2) Limit coal and lignite to 0.5 percent.
3. Coarse Aggregate:
   a. Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
   b. Limit deleterious substances in accordance with ASTM C33/C33M, Table 4 for specified class designation.

C. Admixtures: Unless otherwise approved by Engineer, furnish from one manufacturer.

1. Characteristics:
   a. Compatible with other constituents in mix.
   b. Contain at most, only trace amount chlorides in solution.
   c. Do not use admixtures known to be toxic after concrete is 30 days old.
   d. Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
2. Air-Entraining Admixture: ASTM C260/C260M.
3. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
4. Retarding Admixture: ASTM C494/C494M, Type B.
5. Accelerating Admixture: ASTM C494/C494M, Type C.
6. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F or Type G.
7. Shrinkage Reducing Admixture:
   a. Manufacturers and Products:
      1) BASF Admixtures Inc., Shakopee, MN; Tetraguard AS20.
      2) Euclid Chemical Co., Cleveland, OH; Eucon SRA Series.
      3) W. R. Grace & Co., Cambridge, MA; Eclipse Series.
8. Cementitious Crystalline Waterproofing:
   a. Manufacturer and Product: Xypex Chemical Corporation, Richmond, B.C., Canada; Xypex Admix C-Series (C-500/500NF, C-1000/1000NF, or C-2000/2000NF).
9. Antiwashout Admixture for Tremie Concrete:
   a. Specially developed to prevent cement washout of concrete placed under water.
   b. Manufacturer and Product: BASF Admixtures Inc., Shakopee, MN; Rheomac UW 450.
10. Do not use calcium chloride as an admixture.
11. Admixtures with no standard, ASTM or other, designation may be used where permitted.

D. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water, unless alternative sources of water are permitted.

1. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water shall be less than:
   a. Chloride Content: 1,000 ppm.
   b. Sulfate Content as SO_4: 3,000 ppm.
   c. Alkalis as (Na_2O + 0.658 K_2O): 600 ppm.
   d. Total Solids by Mass: Less than 50,000 ppm.

2.02 ANCILLARY MATERIALS

A. Bonding Agent:

1. Unless otherwise specified, in accordance with the following:
   a. ASTM C881/C881M, Type V.
   b. Two-component, moisture insensitive, 100 percent solids epoxy.
   c. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.

B. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
   a. Dayton Superior Corporation, Kansas City, KS; EDOCO Clean Lift Bond Breaker.
   b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

C. Repair Material:

1. In accordance with requirements of Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
2. In accordance with requirements of Section 03 01 33, Repair of Horizontal Concrete Surfaces.

D. Crack Repair: In accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

2.03 CONCRETE MIX DESIGN

A. General:

1. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
2. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
3. Selection of constituent materials and products in mix design are optional, unless specified otherwise.
4. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range, water-reducing admixture in pumped concrete, in concrete with a water-cementitious materials ratio below 0.50, and in concrete that is part of hydraulic structures, unless otherwise approved by Engineer.
5. Unless otherwise permitted, use water-reducing admixture and high-range, water-reducing admixture in columns, piers, pilasters, and walls.

6. Use water-reducing admixture or high-range, water-reducing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
7. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.
8. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor and coordinated with concrete producer. Fresh properties of concrete shall remain stable to satisfaction of Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.

B. Potential Alkali-Aggregate Reactivity of Concrete:

1. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
2. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C1260 or ASTM C1567.
    a. Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be nondeleteriously reactive in accordance with ASTM C227 or ASTM C1293, with less than 0.04 percent expansion at 1 year for cement-aggregate combinations or less than 0.04 percent expansion at 2 years for combinations with pozzolan or slag.
    b. Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.
    c. Use low-alkali cement or incorporate pozzolans into concrete mixture as necessary to satisfy testing for potential alkali reactivity.

C. Proportions:

1. Design mix to meet aesthetic, durability, and strength requirements.
2. Where fly ash is included in mix, minimum fly ash content shall be a minimum of 15 percent of weight of total cementitious materials.

D. Concrete Shrinkage Limits:

1. Where shrinkage limits are specified, design mix for following shrinkage limits and test in accordance with ASTM C157/C157M, with the following modifications:
   a. Prisms shall be moist cured for 7 days prior to 28-day drying period.
   b. Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
   c. Reported results shall be average of three prisms.
   d. If shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
   e. Unless otherwise specified, results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used or exceed 0.038 percent if 4-inch prisms are used. Aggregate will be rejected if test values exceed these limits.

E. Slump Range at Site:

1. Prior to submitting mix design, consult with concrete producer and select a target slump value at point of delivery, for each application of each design mix. Unless otherwise permitted, target slump value will then be enforced for duration of Project.
2. Design mixes that include a high-range, water-reducing admixture shall have a minimum slump of 2 inches prior to addition of admixture. Unless otherwise permitted, slump shall be 8 inches maximum at point of delivery, for concrete with a high-range, water-reducing admixture.
3. Slump tolerance shall meet requirements of ACI 117:
   a. Target slump less than or equal to 2 inches: +/- 0.5 inch.
   b. Target slump between 2 inches and 4 inches: +/- 1 inch.
   c. Target slump greater than or equal to 4 inches: +/- 1.5 inches.

F. Combined Aggregate Gradation:

1. Combined Gradation Limits: Limits shown are for coarse aggregates and fine aggregates mixed together (combined). Select one of the gradations shown in the following table:

	Combined Gradation Percentage Passing		
Sieve Sizes	1-1/2" Max.	1" Max.	3/4" Max.
2"	100	-	-
1-1/2"	95 - 100	100	-
1"	65 - 85	90 - 100	100

Sieve Sizes	Combined Gradation Percentage Passing		
	1-1/2" Max.	1" Max.	3/4" Max.
3/4"	55 - 75	70 - 90	92 - 100
1/2"	-	-	68 - 86
3/8"	40 - 55	45 - 65	57 - 74
No. 4	30 - 45	31 - 47	38 - 57
No. 8	23 - 38	23 - 40	28 - 46
No. 16	16 - 30	17 - 35	20 - 36
No. 30	10 - 20	10 - 23	14 - 25
No. 50	4 - 10	2 - 10	5 - 14
No. 100	0 - 3	0 - 3	0 - 5
No. 200	0 - 2	0 - 2	0 - 2

2.04 CONCRETE MIXING

A. General: In accordance with ACI 301, except as modified herein.

B. Where cementitious crystalline waterproofing is required, add to concrete at time of batching.

C. Truck Mixers:

1. For every truck, test slump of samples taken per ASTM C94/C94M, paragraph 12.5.1.
2. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

2.05 TEMPERATURE LIMITS

A. For concrete sections with a minimum specified thickness that is greater than 2 feet 6 inches and unless otherwise permitted:

1. Provide documentation that maximum concrete temperature in structure will not exceed 158 degrees F, and maximum temperature differential between center of section and external surfaces of concrete will not exceed 35 degrees F.

2.06 SOURCE QUALITY CONTROL

A. Source Quality Control Inspection: Engineer shall have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

PART 3 EXECUTION

3.01 PLACING CONCRETE

A. Preparation: Meet requirements ACI 301, except as modified herein.

B. Inspection: Notify Engineer and Special Inspector at least 1 full working day in advance before starting to place concrete.

C. Time of Discharge:

1. Concrete shall be discharged and placed in its final position within 90 minutes from the time water and cement is added to the mix.
2. Concrete not placed within the specified time shall be rejected and wasted offsite at the Contractor's expense.

D. Placement into Formwork:

1. Reinforcement: Secure in position before placing concrete.
2. Before depositing concrete, remove debris from space to be occupied by concrete.
3. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep. Slabs less than 1.5 feet thick shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
4. Place concrete as near to its final position as possible to minimize the extent of lateral flow required for positioning.
5. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.
6. Use placement devices, for example chutes, pouring spouts, and pumps as required to prevent segregation.
7. Vertical Free Fall Drop to Final Placement:
   a. Forms 8 Inches or Less Wide: 5 feet.
   b. Forms Wider than 8 Inches: 8 feet, except as specified.
8. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
   a. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
9. Do not use aluminum conveying devices.

10. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
11. Joints in Footings and Slabs:
    a. Ensure space beneath plastic waterstop completely fills with concrete.
    b. During concrete placement, make visual inspection of entire waterstop area.
    c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, and place remaining concrete to full height of slab.
    d. Apply procedure to full length of waterstop.
12. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.
13. Cure concrete as specified in Section 03 39 00, Concrete Curing.

E. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.
4. Conveyor Belts:
    a. Approved by Engineer.
    b. Wipe clean with device that does not allow mortar to adhere to belt.
    c. Cover conveyor belts and chutes.

F. Retempering: Not permitted for concrete where cement has partially hydrated.

G. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping equipment and hoses (conduits) that are not functioning properly.

H. Concrete sections with a minimum specified dimension that is greater than 2 feet 6 inches:

1. Cure and protect concrete in accordance with accepted thermal control plan and as follows:
   a. Minimum curing period shall be 14 days.
   b. Unless otherwise permitted, preserve moisture by maintaining forms in place.
2. Strength measurement shall be representative of in-place concrete within 2 inches of concrete surface.
3. Concrete strength shall be verified through correlation of concrete temperature and compressive strengths established by cylinder compressive tests and in accordance with ASTM C1074.
4. Unless otherwise specified, control concrete temperatures to within specified limits from time concrete is placed until time internal temperature has cooled from its maximum, such that difference between average daily ambient and maximum internal concrete temperature at time of protection removal, is less than specified temperature difference limit.
5. Unless otherwise specified, place one temperature sensor at center of mass of placement and one temperature sensor at a depth 2 inches from center of nearest exterior surface. Place additional sensor at each location to serve as a backup in event that other temperature sensor fails. In addition, provide temperature sensor in shaded location for monitoring ambient onsite temperature.
   a. Unless otherwise specified, monitor temperatures hourly using electronic sensors capable of measuring temperature from 32 degrees F to 212 degrees F to an accuracy of 2 degrees F.
   b. Ensure temperature sensors are operational before placing concrete.
   c. Unless otherwise specified, provide data from sensors to Engineer on a daily basis, until requirements are met.
   d. Compare temperatures and temperature differences with maximum limits specified in Article Temperature Limits every 12 hours, unless otherwise permitted. If either exceeds specified limits, take immediate action as described in accepted thermal control plan to remedy situation. Do not place additional mass concrete until cause of excessive temperature or temperature difference has been identified and corrections are accepted.

I. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Locate expansion, control, and contraction joints where shown on Drawings.

3. Construction Joints:
    a. Unless otherwise shown or permitted, locate construction joints as follows:
        1) Locate construction joints as shown on Drawings or where approved in joint location submittal required in Section 03 15 00, Concrete Joints and Accessories.
        2) Provide vertical construction joints in walls and slabs at maximum spacing of 40 feet, unless shown or approved otherwise.
        3) When vertical expansion, contraction, or control joint spacing does not exceed 60 feet, intermediate construction joints are not required.
        4) Uniformly space vertical construction joints within straight sections of walls and slabs, avoiding penetrations.
4. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
5. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

J. Minimum Time between Adjacent Placements:

1. Construction or Control Joints: 7 days, unless otherwise specified.
2. Construction joint between top of footing or slab, and column or wall: As soon as can safely be done without damaging previously cast concrete or interrupting curing thereof, but not less than 24 hours.
3. Expansion or Contraction Joints: 1 day.
4. For columns and walls with a height in excess of 10 feet, wait at least 2 hours before depositing concrete in beams, girders, or slabs supported thereon.
5. For columns and walls 10 feet in height or less, wait at least 1 hour prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.

K. Consolidation and Visual Observation:

1. Consolidation Equipment and Methods: ACI 301.
2. Provide at least one standby vibrator in operable condition at Site prior to placing concrete.
3. Provide sufficient windows in forms or limit form height to allow for concrete placement through windows and for visual observation of concrete.
4. Vibrate concrete in vicinity of joints to obtain impervious concrete.

L. Hot Weather:

1. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:
   a. Maintain concrete temperature below 90 degrees F at time of placement or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
   b. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
2. Prevent differential temperature between reinforcing steel and concrete.
3. Concrete Curing: As specified in Section 03 39 00, Concrete Curing.

M. Cold Weather Placement:

1. Unless otherwise permitted, shall be in accordance with requirements of ACI 306.1 and as follows:
   a. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
   b. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.
   c. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.
   d. Provide heated enclosures when air temperatures are below 40 degrees F.
   e. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
   f. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.
   g. Cure concrete as specified in Section 03 39 00, Concrete Curing.
      1) Protect concrete from freezing until end of curing period and until concrete has attained a compressive strength of 3,500 psi or design compressive strength if less than 3,500 psi.

2. Provide maximum and minimum temperature sensors placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work. Unless otherwise permitted, record surface temperature of concrete at least once every 12 hours during specified curing period.
3. External Heating Units: Do not exhaust heater flue gases directly into enclosed area as it causes concrete carbonation as a result of concentrated carbon dioxide.
4. Maintain curing conditions as specified in Section 03 39 00, Concrete Curing.

3.02 CONCRETE BONDING

A. Construction Joints in New Concrete Members:

1. Prepare surface of construction joint as specified in Section 03 15 00, Concrete Joints and Accessories.
2. Horizontal Construction Joints Containing Waterstop in New Concrete Walls:
   a. Limit initial concrete placed immediately above waterstop to 18 inches thick maximum.
   b. Place concrete in linear fashion along length of waterstop to fully envelope waterstop with no voids.
   c. Thoroughly vibrate concrete to produce dense placement of concrete at base of joint and adjacent to waterstop.

B. Construction Joints at Existing Concrete:

1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 1/4 inch.
2. Saturate surface with water for 24 hours prior to placing new concrete.

3.03 REPAIRING CONCRETE

A. General:

1. Inject cracks that leak with crack repair epoxy as specified in Section 03 64 23, Epoxy Resin Injection Grouting.
2. Repair defective areas of concrete.
3. Repair horizontal concrete surfaces in accordance with Section 03 01 33, Repair of Horizontal Concrete Surfaces.
4. Repair vertical and overhead concrete surfaces in accordance with Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
5. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Engineer.

B. Tie Holes:

1. Unless otherwise specified, fill with specified repair material.
   a. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.

C. Alternate Form Ties, Through-Bolts:

1. Mechanically roughen entire interior surface of through-hole.
2. Apply bonding agent to roughened surface and drive elastic vinyl plug to half depth.
3. Dry pack entire hole from both sides of plug with nonshrink grout, as specified in Section 03 62 00, Grouting.
4. Use only enough water to dry pack grout.
5. Dry pack while bonding agent is still tacky.
6. If bonding agent has dried, remove bonding agent by mechanical means and reapply new coat of bonding agent.
7. Compact grout using steel hammer and steel tool to drive grout to high density.
8. Cure grout with water.

D. Exposed Metal Objects:

1. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1 inch and then cutting or removing metal object.
2. Repair area of chipped-out concrete as specified for defective areas.

E. Blockouts at Pipes or Other Penetrations: Where shown install in accordance with requirements of Drawings.

3.04 CONCRETE WALL FINISHES

A. Type W-1 (Ordinary Wall Finish):

1. Patch tie holes.
2. Knock off projections.
3. Repair defective areas.
4. Inject cracks in accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

B. Type W-2 (Smooth Wall Finish):

1. Patch tie holes.
2. Grind off fins and other projections.

3. Repair defective areas to provide smooth uniform appearance.
4. Inject cracks in accordance with requirements of Section 03 64 23, Epoxy Resin Injection Grouting.

C. Type W-5 (Finish for Painting):

1. In accordance with requirements for Type W-2 except as follows:
   a. Leave surface ready for painting as specified in Section 09 90 00, Painting and Coating.

D. Type W-7 (Smooth Rubbed Wall Finish):

1. Only water curing will be permitted on walls scheduled to be rubbed.
2. Perform rubbing while green concrete can be physically worked and smoothed without adding other materials, if structurally possible, the day following placement. Finish no later than 3 days after placement has been completed.
3. Remove forms at such a rate that finishing, form tie filling, fin removal, and patching can be completed on same day forms are removed while curing wall.
4. After patches have set sufficiently to permit working on surface, thoroughly saturate entire surface with water for period of 3 hours and rub until uniform surface is obtained.
5. Rub either by hand with carborundum stone of medium-coarse grade or abrasive of equal quality, or mechanically operated carborundum stone.
6. Mechanically operated carborundum stones shall be approved by Engineer before concrete finishing.
7. No cement grout, other than cement paste drawn from concrete itself by rubbing process shall be used.
8. Finish paste formed by rubbing by either brushing or floating as follows:
   a. Brushing:
      1) Carefully strike with clean brush.
      2) Brush in long direction of surface being finished.
   b. Floating:
      1) Spread uniformly over surface and allow to reset.
      2) Finish by floating with canvas, carpet face, or cork float, or rub down with dry burlap.
9. Continue water curing of wall during finishing operation in areas not being rubbed.
10. Move water curing onto rubbed areas as soon as water will not erode rubbed surface.

E. Type W-9 (Grout Cleaned Wall Finish):

1. Meet requirements for Type W-7, except that finish must be accomplished within 7 days of placement.
2. Grout: Mixed with one-part portland cement and one and one half parts fine sand and bonding agent to produce grout with consistency of thick paint. White portland cement shall be substituted for part of gray portland cement in order to produce color matching color of surrounding concrete, as determined by trial patch.
3. Wet surface of concrete sufficiently to prevent absorption of water from grout and apply grout uniformly with brushes or spray gun.
4. Immediately after applying grout, scrub surface vigorously with cork float or stone to coat surface and fill air bubbles and holes.
5. While grout is still plastic, remove excess grout by working surface with rubber float, burlap, or other means. After surface whitens from drying, about 30 minutes at 70 degrees F, rub vigorously with clean burlap. Continue to water cure wall until curing period of 7 days is complete.
6. Latex bonding admixture may be used.

3.05 CONCRETE SLAB FINISHES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
2. Do not use “jitterbugs” or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
3. Finish slab in accordance with specified slab finish.
4. Do not dust surfaces with dry materials nor add water to surfaces.
5. Cure concrete as specified in Section 03 39 00, Concrete Curing.

B. Type S-1 (Steel Troweled Finish):

1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation.
2. Wood float to true, even plane with no coarse aggregate visible.
3. Use sufficient pressure on wood floats to bring moisture to surface.
4. After surface moisture has disappeared, hand steel trowel concrete to produce smooth, smooth dense surface, free from trowel marks.
5. Provide light steel-troweled finish (two trowelings) at air-entrained slabs. Provide hard steel-troweled finish (ringing sound from the trowel) for nonair-entrained slabs.
6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.

7. Power Finishing:
    a. Approved power machine may be used in lieu of or in addition to hand finishing in accordance with directions of machine manufacturer.
    b. Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high and low spots in slab.
    c. Do first steel troweling for slab S-1 finish by hand.

C. Type S-2 (Wood Float Finish):

1. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.
2. Wood float finish to compact and seal surface.
3. Remove laitance and leave surface clean.
4. Coordinate with other finish procedures.

D. Type S-3 (Underside Elevated Slab Finish): When forming is removed, grind off projections on underside of slab and repair defective areas, including small shallow air pockets where schedule of concrete finishes requires:

1. Prepare surfaces to match Type W-2 (Smooth Wall Finish).

E. Type S-5 (Broomed Finish):

1. Finish as specified for Type S-1 floor finish, except use only a light-steel troweled finish, and then finish surface by drawing fine-hair broom lightly across surface.
2. Broom in same direction and parallel to expansion joints, or, in case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.

F. Type S-6 (Sidewalk Finish):

1. Slope walks down 1/4 inch per foot away from structures, unless otherwise shown.
2. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
3. Broom surface at right angles to direction of traffic or as shown.
4. Lay out sidewalk surfaces in blocks, as shown or as directed by Engineer, with grooving tool.

G. Concrete Curbs:

1. Float top surface of curb smooth and finish all discontinuous edges with steel edger.
2. After concrete has taken its initial set, remove front form and give exposed vertical surface an ordinary wall finish, Type W-1.

3.06 CONCRETE SLAB TOLERANCES

A. Slab Tolerances:

1. Exposed Slab Surfaces: Comprise of flat planes as required within tolerances specified.
2. Slab Finish Tolerances and Slope Tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end blocks, nor low spots that allow block of twice the tolerance in thickness to pass under supported 10-foot straightedge.
3. Slab Type S-A: Steel gauge block 5/16 inch thick.
4. Slab Type S-B: Steel gauge block 1/8 inch thick.
5. Slab Type S-A and S-B: Finish Slab Elevation: Slope slabs to floor drain and gutter and shall adequately drain regardless of tolerances.
6. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

B. Slab Elevation and Thickness:

1. Finish Slab Elevation: Slope slabs to floor drains and gutter. Slabs shall adequately drain regardless of tolerances.
2. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

3.07 BEAM AND COLUMN FINISHES

A. Type B-1: Match wall Type W-1.

B. Type B-2: Match wall Type W-2.

C. Type B-5:

1. Repair rock pockets.
2. Fill air voids.
3. Match wall Type W-5.

3.08 BACKFILL AGAINST STRUCTURES

A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.

B. Refer to General Structural Notes on Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.

C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.09 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test specimens onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Unless otherwise specified, sample concrete for testing for making test specimens, from point of delivery.
3. When concrete is pumped, sample and test air content at point of delivery and at point of placement.
    a. Each Concrete Mixture: Provided results of air content tests for first load of the day are within specified limits, testing need only be performed at point of delivery for subsequent loads of that concrete mixture except that testing should be performed at point of placement every 4 hours or 75 cubic yards, whichever results in the greatest number of tests from the point of placement.
4. Evaluation will be in accordance with ACI 301 and Specifications.
5. Test specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
6. Frequency of testing may be changed at discretion of Engineer.
7. Pumped Concrete: Take concrete samples for slump, ASTM C143/C143M, and test specimens, ASTM C31/C31M and ASTM C39/C39M, and shrinkage specimens (ASTM C157/C157M) at placement (discharge) end of line.
8. If measured air content at delivery is greater than specified limit, check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents. Concrete that has failed to meet requirements of Contract Documents shall be rejected.

B. Concrete Strength Test: In Accordance with Article Field Quality Assurance Testing for Acceptance.

C. Shrinkage Tests:

1. When required to conform to shrinkage limits, collect actual concrete materials being batched and before liquids have been added to mix.
2. Mix sampled material in a laboratory at proportions matching batched concrete.
3. Test shrinkage characteristics every 5,000 cubic yards of concrete used on job and every 3 months during construction when compression test cylinders are made.
4. Concrete Shrinkage Limits:
    a. Test in accordance with ASTM C157C157M, with the following modifications:
        1) Prisms shall be moist cured for 7 days prior to 28-day drying period.
        2) Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
        3) Reported results shall be average of three prisms.
        4) If drying shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
        5) Results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used or exceed 0.038 percent if 4-inch prisms are used.
        6) If 7-day or 14-day shrinkage tests results exceed shrinkage limits established by design mix testing, furnish additional 14 days of water curing beyond original curing period, for concrete surfaces of hydraulic structures represented by prisms. Modify concrete mix design to reduce shrinkage prior to casting additional concrete on Project.

D. High-Range, Water-Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on Project.

1. Segregation Test Objective: Concrete with 4-inch to 8-inch slump shall stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump test.
2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
3. Reject concrete if mortar or moisture separates and flows out of mix.

E. Cold Weather Placement Tests:

1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
   a. Six extra test cylinders from last 100 cubic yards of concrete.
   b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
2. These specimens shall be in addition to those cast for lab testing.
3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
5. Test cylinders in accordance with applicable sections of ASTM C31/ C31M and ASTM C39/C39M.
6. Use test results to determine specified strength gain prior to falsework removal or for prestressing.

F. Tolerances:

1. Walls: Measure and inspect walls for compliance with tolerances specified in Section 03 10 00, Concrete Forming and Accessories.
2. Slab Finish Tolerances and Slope Tolerances:
   a. Make floor flatness measurements day after floor is finished and before shoring is removed to eliminate effects of shrinkage, curing, and deflection.
   b. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
   c. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

G. Liquid-Tightness Tests:

1. Purpose: To determine integrity and liquid-tightness of finished exterior and interior concrete surfaces of liquid containment structures.
2. Test the following structures for liquid-tightness:
   a. Add Project-specific structure 1.
   b. Add Project-specific structure 2.
3. Water for initial tightness test shall be provided by Contractor.
4. After testing has been completed, dispose of test water in a manner approved by Owner.

5. Liquid-Tightness Test Requirement:
   a. Perform tightness tests in accordance with ACI 350.1 and as specified herein.
   b. Do not place backfill or install brick facing, grout topping slab, coatings, or other work that will cover concrete surfaces until tightness testing has been completed and approved.
   c. Measure evaporation, precipitation, and temperature as specified.
6. Measure water surface at two points 180 degrees apart when possible where attachments, such as ladders exist, at 24-hour intervals.
7. Acceptance Criteria:
   a. Volume loss shall not exceed 0.050 percent of contained liquid volume per 24-hour period, adjusted for evaporation, precipitation, and temperature.
   b. Acceptance that structure has passed tightness test shall be based on total volume loss at end of specified test period.
8. Repairs When Test Fails:
   a. Dewater structure; fill leaking cracks with crack repair epoxy as specified in Section 03 64 23, Epoxy Resin Injection Grouting.
   b. Patch areas of damp spots previously recorded, and repeat water leakage test in its entirety until structure successfully passes test.

3.10 FIELD QUALITY ASSURANCE TESTING FOR ACCEPTANCE

A. An independent testing agency shall be retained by the Contractor to inspect, sample, and test materials and concrete production as required by the Contract Documents for quality assurance and acceptance.

1. Material furnished or work performed that fails to conform to the Contract Documents shall be immediately reported by independent testing agency as a deficiency to Engineer, Owner, Contractor, and concrete supplier.
2. Independent Testing Agency will report test and inspection results to the Engineer, Owner, Contractor, and concrete supplier within 24 hours after tests and inspections are performed.
3. Strength test reports will include location in the work where the concrete represented by each test was deposited, date and time sample was obtained, and batch ticket number.
4. Strength test report will include detailed information of storage and curing of specimens before testing.
5. Minimum frequency of testing shall include one composite sample for each 100 cubic yards or 5,000 square feet of surface area of slabs or wall or fraction thereof.

6. Frequency of testing may change at the discretion of the Engineer. Each sample shall include the following:
   a. Strength test in accordance with ASTM C31/C31M and ASTM C39/C39M.
   b. Slump in accordance with ASTM C143/C143M.
   c. Air content in accordance with ASTM C231 or ASTM C173/C173M.
   d. Temperature in accordance with ASTM C1064/C1064M.
   e. Density in accordance with ASTM C138/C138M.
7. Each sample shall include a minimum of four strength test specimens, which shall be 6-inch by 12-inch cylinders and shall be tested as follows:
   a. One specimen to be tested at 7 days for information.
   b. A minimum of two specimens to be tested at age of 28 days for acceptance. Concrete strength for acceptance shall be the average of the two specimens.
   c. A minimum of one spare specimen shall be tested as directed by the Engineer.
   d. See Paragraph Cold Weather for additional specimen requirements.
8. If result of 7-day concrete test is less than 50 percent of the specified 28-day strength, extend period of moist curing specified in Section 03 39 00, Concrete Curing, by 7 additional days.

3.11 MANUFACTURER'S SERVICES

A. Provide representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.

1. Concrete Producer Representative:
   a. Observe how concrete mixes are performing.
   b. Be present during first placement of each type of concrete mix.
   c. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
   d. Establish control limits on concrete mix designs.
   e. Provide equipment for control of concrete redosing for air entrainment or high-range, water-reducing admixture, superplasticizers, at Site to maintain proper slump and air content if needed.
2. Admixture Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.

3. Cementitious Crystalline Waterproofing Admixture Representative: Supervise the mix design and concrete mixing in person for the initial batching. Available for consultation to provide consultation as required to ensure proper use and performance of product.
4. Bonding Agent Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.

3.12 PROTECTION OF INSTALLED WORK

A. After curing as specified in Section 03 39 00, Concrete Curing, and after applying final floor finish, cover slabs with plywood or particle board or plastic sheeting or other material to keep floor clean and protect it from material and damage as a result of other construction work.

B. Repair areas damaged by construction, using specified repair materials and approved repair methods.

3.13 SCHEDULE OF CONCRETE FINISHES

A. Form Tolerances: As specified in Section 03 10 00, Concrete Forming and Accessories.

B. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form Tolerances
Exterior Wall Surfaces		
Abovegrade/exposed (above point 6" below finish grade)	W-2	W-B
Abovegrade/covered with brick veneer or other finish material	W-1	W-A
Backfilled/waterproofed (below point 6" below finish grade)	W-1	W-A
Backfilled/not waterproofed (below point 6" below final grade)	W-1	W-A

Area	Type of Finish	Required Form Tolerances
Interior Wall Surfaces		
Open top water-holding tanks and basins/not painted or coated	W-2	W-A
Covered water-holding tanks and basins/not painted or coated	W-1	W-A
Buildings, pipe galleries, and other dry areas/not painted or coated	W-2	W-A
Buildings, pipe galleries, and other dry areas/painted or coated	W-5	W-A
Exterior Slabs		
Roof slab/exposed	S-5	S-B
Roof slab/covered with roofing material	S-1	S-A
Water-holding tanks and basins/top of wall	S-5	S-B
Top of footing	S-2	S-A
Stairs and landings	S-5	S-B
Sidewalks	S-6	S-B
Other exterior slabs	S-5	S-A
Interior Slabs		
Buildings, pipe galleries, and other dry areas	S-1	S-B
Hydraulic channels and basins	S-1	S-A
Underside of elevated slabs	S-3	S-A
Beams and Columns		
Beams/not coated	B-2	B-A
Beams/painted	B-5	B-A
Columns/not coated	B-2	C-A
Columns/painted	B-5	C-A

3.14 SUPPLEMENTS

A. Requirements of concrete mix designs and Preplacement checklist following “End of Section,” are a part of this specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, Class: Structural.
2. Concrete Mix Design, Class: Concrete Fill.
3. Concrete Mix Design, Class: Civil.
4. Concrete Mix Design, Class: Riprap.
5. Preplacement Checklist.

END OF SECTION

CONCRETE MIX DESIGN, CLASS: STRUCTURAL

A. Mix Locations:

1. Typical, unless otherwise specified.
2. Hydraulic structures as defined herein.

B. Exposure Categories and Classifications: F3S1P2C2.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
2. Minimum concrete compressive strength (f'c) shall be 4,500 psi at 28 days.
3. Designed to conform to shrinkage limits. Conformance shall be demonstrated through test batches.
4. Mix design shall produce a plastic and workable mix.
5. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
6. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in.‡	Air Content (%)*
3/4	6.0
1	6.0
1-1/2	5.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is +/-1.5 percent.

§Air contents apply to total mixture.

7. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in mix design, as follows:
   a. Fly Ash and other Pozzolans: 15 percent minimum, 25 percent maximum.
   b. Total cementitious materials include ASTM C150/C150M cement.

8. Provide cementitious materials in accordance with one of the following:
    a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
    b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
        1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
        2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
9. Unless otherwise permitted, minimum cementitious materials content in mix design shall be as follows:
    a. 500 pounds minimum cement per cubic yard (not including other cementitious materials).
    b. 515 pounds per cubic yard for concrete with 1-1/2-inch nominal maximum size aggregate.
    c. 535 pounds per cubic yard for 1-inch nominal maximum size aggregate.
    d. 560 pounds per cubic yard for 3/4-inch nominal maximum size aggregate.
    e. 580 pounds per cubic yard for 1/2-inch nominal maximum size aggregate.
    f. 600 pounds per cubic yard for 3/8-inch nominal maximum size aggregate.
    g. Unless otherwise permitted, limit cementitious materials content to 100 pounds per cubic yard greater than specified minimum cementitious materials content in mix design.
10. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
    a. Limits are stated in terms of chloride ions in percent by weight of cement.
11. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
12. Use cementitious crystalline waterproofing admixture as specified herein in all hydraulic structures.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CLASS: CONCRETE FILL

A. Mix Locations:

1. Electrical duct banks.
2. Where Concrete Fill is specified in Contract Documents.

B. Exposure Categories and Classifications: F1S1P0C1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 3,500 psi at 28 days.
3. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
3/4	5.0
1	4.5
1-1/2	4.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is +/-1.5 percent.

§Air contents apply to total mixture.

4. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.

5. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CLASS: CIVIL

A. Mix Locations: Concrete curbs and sidewalks.

B. Exposure Categories and Classifications: F3S1P1C2.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.42.
2. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days.
3. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
3/4	6.0
1	6.0
1-1/2	5.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is +/-1.5 percent.

§Air contents apply to total mixture.

4. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in a mix design, as follows:
   a. Fly Ash and other Pozzolans: 15 percent minimum, 25 percent maximum.
   b. Total cementitious materials include ASTM C150/C150M.
5. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
6. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent, unless otherwise specified.

a. Limits are stated in terms of chloride ions in percent by weight of cement.
b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

7. Fiber Reinforcement:
a. Where required in Drawings, provide polypropylene micro-fibers in design mix in accordance with Section 03 24 00, Fibrous Reinforcing.
b. Add fiber-reinforcement to mix in concrete plant.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CLASS: RIPRAP

A. Mix Locations: Filling voids in riprap embankments.

B. Exposure Categories and Classifications: F3S1P1C2.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.44.
2. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days.
3. Mix design shall produce a plastic and workable mix.
4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
3/8	7.5
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is +/-1.5 percent. §Air contents apply to total mixture.	

5. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in a mix design, as follows:
   a. Fly Ash and other Pozzolans: 15 percent minimum, 25 percent maximum.
   b. Total cementitious materials include ASTM C150/C150M.
6. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
7. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.

b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

Preplacement Checklist		
Description and Location of Placement:		
Size of Placement (CY):		
Projected Time and Duration of Placement:	Date: Anticipated Start Time: Projected Duration (hours):	
Concrete Mix ID:		
Target Slump:		Tolerance +/-1 inch for target between 2 inches and 4 inches. Tolerance +/- 1.5 inch for target greater than 4 inches
Target Air		Tolerance: +/- 1.5 percent
Precautions Taken for Environmental Protection:		
Curing Method:		
Other (Admixtures, etc.):		

Signature of Contractor's Project Manager or Superintendent: _____

SECTION 03 39 00
CONCRETE CURING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 308.1, Specification for Curing Concrete.
2. ASTM International (ASTM):
   a. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   b. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
3. NSF International: 61, Drinking Water System Components – Health Effects.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturers' data indicating compliance with the requirements specified herein for the following products:
   a. Evaporation retardant.
   b. Curing compound.
   c. Penetrating water repellent sealer.
2. Curing methods proposed for each type of element such as footing, slab, walls, beams, and columns in each facility.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
   a. Curing compound showing moisture retention requirements.

PART 2 PRODUCTS

2.01 MATERIALS

A. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315 Type I, Class A.

B. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; MasterKure ER 50.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

C. Penetrating Water Repellent Sealer: Water based, ready to use, single component, silane/siloxane, penetrating, clear water repellant sealer.

1. Viscosity: 50 cps.
2. Flash Point: 200 degrees F.
3. NCHRP No. 244 Reduction in Chloride Content:
   a. Average: 82 percent.
   b. Minimum Required: 75 percent.
4. NCHRP No. 244 Reduction in Weight Gain:
   a. 21 Days: 85 percent.
   b. VOCs: 50 g/l.
   c. Depth of Penetration: 1/4 inch.
5. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee MN; MasterProtect H 400.
   b. Euclid Chemical Co.; Baracade WB 244.

D. Water: Clean and potable, containing less than 500 ppm of chlorides.

PART 3 EXECUTION

3.01 CONCRETE CURING

A. General:

1. Cure all concrete in accordance with Project Specifications and ACI 308.1.
2. Where surfaces are to receive coatings, painting, cementitious material, or other similar finishes, use only water curing procedures. Refer to Interior Finish Schedule on Drawings for surfaces to receive coatings.
3. Use only water curing on water retaining structures.
4. Where curing compound cannot be used, water curing as described below or special methods using moisture shall be agreed upon by Engineer prior to placing concrete.

5. As required in Section 03 30 00, Cast-in-Place Concrete, if result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified below, by 7 additional days.

B. Use one of the following methods as approved by Engineer:

1. Vertical Surfaces:
   a. Method 1: Leave concrete forms in place and keep surfaces of forms and concrete wet for 7 days.
   b. Method 2: Continuously sprinkle with water 100 percent of exposed surfaces for 7 days starting immediately after removal of forms.
   c. Method 3: Apply curing compound, where allowed, immediately after removal of forms.
2. Horizontal Surfaces:
   a. Method 1: Protect surface by water ponding for 7 days.
   b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.
   c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet for 7 days.
   d. Method 4: Continuously sprinkle exposed surface for 7 days.
   e. Method 5: Apply curing compound, where allowed, immediately after final finishing when surface will no longer be damaged by traffic.

3.02 CURING COMPOUND APPLICATION

A. Apply in accordance with manufacturer's instructions.

B. Coat shall have sufficient thickness to satisfy water retention requirements in a single coat.

C. Reapply as needed and as directed by the Engineer.

3.03 EVAPORATION RETARDANT APPLICATION

A. Use on flatwork when environmental conditions are anticipated to cause rapid drying of the concrete surface. Do not use evaporation retardant on potable water structures, unless product is NSF 61 approved.

B. Spray onto surface of fresh flatwork concrete immediately after screeding to react with surface moisture.

C. Reapply as needed to ensure a continuous moist surface until final finishing is completed.

3.04 PENETRATING WATER REPELLENT SEALER APPLICATION

A. Apply where indicated on Interior Finish Schedule on Drawings.

B. Before application and with Work above completed, water cure concrete walls and floors for a minimum of 28 days to receive sealer, keep clean, unpainted, and free from membrane curing compounds.

C. Concrete and masonry to receive penetrating sealer shall be dry for a minimum 24 hours immediately prior to application.

D. Apply per manufacturer's recommendations utilizing low pressure airless spray equipment.

1. Actual coverage and number of coats to be determined by field test sample application and water absorption testing. Final approval by Owner is required.

E. Apply at a coverage rate of 125 square feet per gallon to 200 square feet per gallon. Cure penetrating sealer on concrete and masonry surfaces for the minimum time recommended by manufacturer prior to allowing contact including foot or vehicular traffic.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

B. Provide penetrating water repellent sealer manufacturer's representative to demonstrate proper application of product.

C. Provide curing compound manufacturer's representative to demonstrate proper application of curing compound to show coverage in one coat.

END OF SECTION

SECTION 03 62 00
GROUTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   b. C307, Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings.
   c. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   d. C579, Standard Test Methods for Compressive Grout Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   e. C882, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
   f. C939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   g. C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   h. C1107/C1107M, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
   i. C1181, Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
   j. D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data of grouts.
2. Proposed method for keeping existing concrete surfaces wet prior to placing nonshrink grout.
3. Forming method for fluid grout placements.
4. Curing method for grout.

B. Informational Submittals:

1. Manufacturer's Written Instructions:
   a. Adding fiber reinforcing to batching.
   b. Mixing of grout.
2. Manufacturer's proposed training schedule for grout work.
3. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements.
   a. Grout free from chlorides and other corrosion-causing chemicals.
   b. Nonshrink grout properties of Category II and Category III, verifying expansion at 3 days or 14 days will not exceed the 28-day expansion and nonshrink properties are not based on gas or gypsum expansion.
4. Manufacturer's Certificate of Proper Installation.
5. Statements of Qualification: Grout manufacturer's representative.
6. Test Reports:
   a. Test report for 24-hour evaluation of nonshrink grout.
   b. Test results and service report from demonstration and training session.
   c. Field test reports and laboratory test results for field-drawn Samples.
7. List of Contractor's equipment installation staff trained by grout manufacturer's representative in:
   a. Nonshrink grout installation and curing.

1.03 QUALIFICATIONS

A. Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of 1-year experience that has resulted in successful installation of grouts similar to those for this Project.

B. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Nonshrink Grout Test Form, attached at the end of this section. Provide independent testing laboratory test results for testing conducted within last 18 months.

1.04 GUARANTEE

A. Manufacturer's guarantee shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.

B. Manufacturer guarantees participation with Contractor in replacing or repairing grout found defective due to faulty materials, as determined by industry standard test methods.

PART 2 PRODUCTS

2.01 NONSHRINK GROUT SCHEDULE

A. Furnish nonshrink grout (Category I, II, and III) for applications as indicated in the following schedule:

Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Filling tie holes	I	I	I
Blockouts for gate guides	I or II		II
Precast joints	I or II		II
Column baseplates single-story	I or II		II
Machine bases 25 hp or less	II	II	II
Form Tie-Through bolt openings	II	II	II
Machine bases 26 hp and up	III	III	III
Baseplates and/or soleplates with vibration, thermal movement, etc.	III	III	III

2.02 NONSHRINK GROUT

A. Category I:

1. Nonmetallic and nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in Accordance with ASTM C1107/C1107M:
   a. Grout shall have flowable consistency.
   b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.
5. Minimum strength of flowable grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.

6. Manufacturers and Products:
    a. BASF Building System, Inc., Shakopee, MN; MasterFlow 100.
    b. Euclid Chemical Co., Cleveland, OH; NS Grout.
    c. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.
    d. US MIX Co., Denver, CO; US SPEC GP Grout.
    e. Five Star Products Inc., Fairfield, CT; Five Star Grout.

B. Category II:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in Accordance with ASTM C1107/C1107M:
    a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
    b. Temperatures of 40 degrees F, 80 degrees F, and 90 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturers and Products:
    a. BASF Building Systems, Inc., Shakopee, MN; MasterFlow 928.
    b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
    c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
    d. Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.
    e. US MIX Co., Denver, CO; US SPEC MP Grout.

C. Category III:

1. Metallic and nongas-liberating.
2. Prepackaged aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in Accordance with ASTM C1107/C1107M:
    a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
    b. Temperatures of 40 degrees F and 100 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.

6. Minimum strength of fluid grout, 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; MasterFlow 885.
   b. Euclid Chemical Co, Cleveland, OH; Hi-Flow Metallic Grout.

PART 3 EXECUTION

3.01 GROUT

A. General: Mix, place, and cure grout in accordance with grout manufacturer's representative's training instructions.

B. Form Tie-through Bolt Holes: Provide nonshrink grout, Category II, fill space with dry pack dense grout hammered in with steel tool and hammer.

C. Through-bolt Holes: Coordinate dry pack dense grout application with vinyl plug in Section 03 10 00, Concrete Forming and Accessories, and bonding agent in Section 03 30 00, Cast-in-Place Concrete.

D. Form Snap-tie Hole: Fill tie hole in accordance with requirements of Section 03 30 00, Cast-in-Place Concrete.

3.02 GROUTING MACHINERY FOUNDATIONS

A. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material. Surface roughness in accordance with manufacturer's written instructions.

B. Clean metal surfaces of all paint, oil, grease, loose rust, and other foreign material that will be in contact with grout.

C. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts. Remove wedges after grout is set and pack void with grout.

D. Form with watertight forms at least 2 inches higher than bottom of plate.

E. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's representative's training instructions.

F. If grout cannot be placed from one edge and flowed to the opposite edge, air vents shall be provided through the plate to prevent air entrapment.

G. Radius all corners of grout pad.

3.03 FIELD QUALITY CONTROL

A. General:

1. Performed by Project representative's inspection staff.
2. Perform the following quality control inspections. The grout manufacturer's representative shall accompany the Project representative's inspection staff on the first installation of each size and type of equipment.

B. Evaluation and Acceptance of Nonshrink Grout:

1. Inspect the surface preparation of concrete substrates onto which nonshrink grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
2. Inspect preparation and application of nonshrink grout form work for conformance to the manufacturer's recommendations.
3. Conduct a final review of completed nonshrink grout installation for conformance to these Specifications.
4. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
5. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/C1107M.
6. For large grout applications, make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
7. Consistency: As specified in Article Nonshrink Grout. Flow cone test in accordance with ASTM C939. Grout with consistencies outside range requirements shall be rejected.
8. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
9. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.
10. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
11. Perform bleeding test in accordance with ASTM C940 to demonstrate grout will not bleed.
12. Store cubes at 70 degrees F.

13. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.
14. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

3.04 MANUFACTURER'S SERVICES

A. General:

1. Coordinate demonstrations, training sessions, and applicable Site visits with grout manufacturer's representative. Allow 2 week notice to grout manufacturer's representative for scheduling purposes.
2. Provide and conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of grout.
3. Necessary equipment and materials shall be available for demonstration.
4. Conduct training prior to equipment mount installation work on equipment pads.
5. Training for each type of grout shall be not less than 4 hours' duration.

B. Nonshrink Grout Training:

1. Training is required for all Type III grout installations.
2. Provide nonshrink grout installation training by the qualified grout manufacturer's representative for Contractor's workers that will be installing nonshrink grout for baseplates and equipment mounts. Schedule training to allow Engineer's attendance.
3. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and form tie-through bolt holes to provide actual on-the-job training.
4. Use minimum of 5 bags for each grout Category III. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Include recommended grout curing methods in the training.
6. Transport test cubes to independent test laboratory and obtain test reports.
7. Training by manufacturer's representative does not relieve Contractor of overall responsibility for this portion of the work.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is part of this specification.

1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

SUPPLEMENT 1

_____
(Test Lab Name)

_____
(Address)

_____
(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain five bags of each type of grout.

1. From intended grout supplier for Project.
2. Five bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A. Product data and warranty information contained in company literature and data? Yes_____ No_____

B. Literature and bag information meet specified requirements? Yes_____ No_____

C. Manufacturer guarantees grout as specified in Article Guarantee? Yes_____ No_____

D. Guarantee extends beyond grout replacement value and allows participation with Contractor in replacing and repairing defective areas? Yes_____ No_____

E. Water demands and limits printed on bag? Yes_____ No_____

F. Mixing information printed on the bag? Yes_____ No_____

G. Temperature restrictions printed on bag? Yes_____ No_____

*Rejection of a grout will occur if one or more answers are noted NO.

GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____
2. List expiration date. _____
3. Weigh bags and record weight. _____

Owner's Representative will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of three bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10-gallon pail.
2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).
3. Use maximum water allowed per water requirements listed in bag instructions.
4. Mix grout to maximum time listed on bag instructions.
5. In accordance with ASTM C939 (flow cone) determine time of mixed grout through the flow cone. _____ seconds
6. Add water to attain 20- to 30-second flow in accordance with ASTM C939.
7. Record time of grout through cone at new water demand. _____ seconds
8. Record total water needed to attain 20- to 30-second flow. _____ pounds
9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, ASTM C1107/C1107M will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.
2. Place one can of grout in tub of ice water and leave one can at ambient temperature.
3. Cover top of both cans with glass or plastic plate preventing evaporation.
4. Maintain 38 degrees F to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1 hour.

5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and Category III):

1. Divide the remaining grout into two 3-gallon cans. Place the cans into the 40-degree F and 90-degree F containers and leave for 20, 40, and 60 minutes. Every 20 minutes, remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4 inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement, test mix the grout with the drill mixer for 10 seconds. Take a ASTM C939 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 degrees F and 90 degrees F.

   a. 20 min _____, sec. @ 40 degrees F.

   b. 40 min _____, sec. @ 40 degrees F.

   c. 60 min _____, sec. @ 40 degrees F.

   d. 20 min _____, sec. @ 90 degrees F.

   e. 40 min _____, sec. @ 90 degrees F.

   f. 60 min _____, sec. @ 90 degrees F.

All Category II and Category III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

_____ _____

Qualified Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with ASTM C1107/C1107M for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are less than 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____ _____

Signature of Independent Testing Laboratory Date Test Conducted

SECTION 03 63 00
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. International Code Council (ICC):
   a. 2018 International Building Code (IBC).
   b. Evaluation Services Reports.
4. NSF International (NSF): 61, Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer's catalog information.

B. Informational Submittals:

1. Manufacturer's instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
2. Manufacturer's written letter of certification identifying installer's qualifications to install products.
3. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: At least three similar projects with same products within last 3 years.
2. Installer: Trained and certified by manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to governing IBC requirements for doweling of steel reinforcing bars in cracked concrete. See General Notes on Drawings for governing IBC version.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Mixed Adhesive: Nonsag, light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runout.
7. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
8. Manufacturers and Products:
   a. Hilti, Inc., Plano, TX; HIT-RE 500-V3 (ESR-3814) or HIT-HY 200 (ESR-3187) Adhesive Anchors.

b. Powers Fasteners or Dewalt, Towson, MD; PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508) or SET-G3 Epoxy Adhesive Anchors (ESR-4057).

B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

C. Reinforcing Dowels: As specified in Section 03 21 00, Steel Reinforcement.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes:
   a. Electric or pneumatic rotary type with medium or light impact.
   b. Hollow drills with flushing air systems are preferred.
2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.

C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.

D. Doweling:

1. Install per details shown on Drawings and in accordance with adhesive manufacturer's instructions.
2. When using epoxy anchors, dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
3. Bent Bar Dowels: Where edge distances are critical, and intersection with steel reinforcement is likely, drill hole at 10-degree angle or less and use prebent reinforcing bars.

E. Adhesive:

1. Install in accordance with written manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Proof Loading:

1. To be performed where continuous inspection of concrete dowels is required.
2. Testing will be performed by Independent Testing Agency.
3. Proof loading to be performed only after adhesive has achieved proper cure per manufacturer's requirements.
4. Testing will be conducted on minimum of 5 percent of installed dowels, with a minimum of two tension tests. A minimum of two cartridges per box or packaging unit will be tested.
5. Testing will be conducted in accordance with ASTM E488 and as follows:
    a. Performance of a static tension test of each test dowel.
    b. Test apparatus reaction base will not interfere with bond failure of dowel but will preclude a concrete pullout cone failure.
    c. Each test dowel will be tested at a proof load equal to the lesser of 80 percent of the yield strength of the dowel bar or 50 percent of calculated ultimate load based on adhesive bond strength.
    d. Test load to be maintained for a minimum of 30 seconds without visible signs of movement of dowel or drop in gauge reading.
6. Failure of dowel bar or failure within base concrete will cause dowel to be rejected. For each rejected dowel, two additional dowels will be tested. Replace rejected dowels as approved by Engineer.

B. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

1. Installation and inspection shall be in accordance with the applicable ICC Evaluation Services Report requirements.
2. Continuous inspection required where noted on Drawings and where concrete dowels are installed in overhead applications.
3. Periodic inspection required where continuous inspection is not specified.
4. Verification of dowel installation in accordance with manufacturer's published instructions.

C. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 03 64 23
EPOXY RESIN INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C882, Standard Specification for Test Method for Bond Strength of Epoxy Resin System Used with Concrete by Slant Shear.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. D638, Standard Test Method for Tensile Properties of Plastics.
   d. D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
   e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
   f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
2. National Sanitation Foundation (NSF):
   a. Standard 60, Standard for Drinking Water Treatment and Chemicals – Health Effects.
   b. Standard 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. Hydraulic Structure: Liquid containment structure and/or structure designed to mitigate liquid infiltration.

D. Injection: Method of bonding together, addressing or eliminating leakage through cracks or joints by installing resin under pressure to fill the void in crack or joint.

E. Joint: A planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements and may contain embedded waterstops.

F. Leak or Leakage: Crack or joint exhibiting presence of moisture, sign of efflorescence, intermittently wet to touch, or continuous flow of liquid.

G. Narrow Cracks: Width equal to or less than 0.015 inch.

H. Wide Cracks: Wider than 0.015 inch.

1.03 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for epoxy resin.
2. Technical data for metering, mixing, and injection equipment.
3. Depth of penetration, length, material used, and procedures where epoxy is approved for use.
4. Marked up drawings of proposed epoxy injection repair crack locations, widths, and lengths and direction on structure.

B. Informational Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy resins.
2. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements. Certified test results for each batch of epoxy resin.
3. Statements of Qualification for Epoxy Resin:
   a. Manufacturer's Site representative.
   b. Injection applicator.
   c. Injection pump operating technician.
4. Sample of epoxy resin two component ratio and injection pressure test records for concrete crack repair work.
5. Installation instructions for repairing core holes with repair mortar.
6. Health and Safety Plans for confined space entry and acid flushing work. Test results of epoxy resin bond tests.
7. Epoxy resin two component ratio and injection pressure test records for concrete crack repair work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staffs:

1. Manufacturer's Site Representative:
   a. Capable of instructing successful methods of epoxy injection process for concrete structure.
   b. Understands and is capable of explaining technical aspects of correct material selection and use.
   c. Experienced in operation, maintenance, and troubleshooting of application equipment.

2. Injection Crew and Job Foreman:
   a. Provide written and verifiable evidence showing compliance with the following requirements:
      1) Licensed or certified by epoxy resin material manufacturer.
      2) Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection, including 2,000 linear feet of wet crack injection to stop water leakage.

B. Injected Epoxy Resin:

1. Fill cracks and construction joints with minimum resin depth penetration no less than 90 percent of:
   a. Full thickness of concrete section for cracks or joints.
   b. Depth between waterstop and inside face of structure for joints with an embedded waterstop.

C. Injected cracks and joints which leak shall be considered deficient work irrespective of depth of penetration. Reinjection of deficient work or, with approval of Engineer, provide other repairs to eliminate leakage.

D. Bond Strength Test for Epoxy Resin:

1. Concrete failure before resin failure.
2. 1,500 psi minimum bond strength per ASTM C882 test requirements with no failure of either concrete or epoxy resin.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package resin material in new sealed containers and label with following information:
   a. Manufacturer's name.
   b. Product name and lot number.
   c. ANSI Hazard Classification.
   d. ANSI recommended precautions for handling.
   e. Mix ratio by volume for components.

B. Storage and Protection: Store epoxy resin material containers in accordance with manufacturer's printed instructions and at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and accessories specified in this section shall be products of:

1. BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; SCB Concresive Series products that meet properties indicated in Paragraph Uncured Resin Properties.
2. Sika Corp., Lyndhurst, NJ; Sikadur Series products that meet properties below.
3. Euclid Chemical Co., Cleveland, OH; Euco Series (Euco #452 Epoxy System) products that meet properties below.

2.02 EPOXY INJECTION RESIN

A. Two-component A and B structural epoxy resin for injection into cracks or joints or other voids in concrete structures for bonding or grouting.

B. Uncured Resin Properties:

1. When mixed in ratio specified on resin container label:

	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Pot Life (60-gram mass) @ 77, plus or minus 4 deg F	As specified in Article Source Quality Control	13 to 25 minutes	15 to 30 minutes
Pot Life (60-gram mass) @ 100, plus or minus 4 deg F	As specified in Article Source Quality Control	3 to 10 minutes	10 to 20 minutes
Viscosity @ 40, plus or minus 3 deg F	Brookfield RVT Spindle No. 4 @ 20 rpm	4,400 cps	600 cps
Viscosity @ 75 deg F to 77 deg F	Brookfield RVT Spindle No. 2 @ 20 rpm	375 to 350 cps	175 to 140 cps

C. Epoxy Resin Properties: When cured for 7 days at 77 degree F, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Ultimate Tensile Strength, psi	ASTM D368	8,000 min.	5,000 min.
Tensile Elongation @ Break, percent	ASTM D638	4.2 max.	3.0 max.
Flexural Strength, psi	ASTM D790	10,000 min.	10,000 min.
Flexural Modulus, psi	ASTM D790	5.5×10^5 min.	4.5×10^5 min.
Compressive Yield Strength, psi	ASTM D695*	15,000 min.	12,000 min.
Compressive Modulus, psi	ASTM D695*	4.0×10^5 min.	4.0×10^5 min.
Heat Deflection Temperature	ASTM D648*	130 deg F min.	140 deg F min.
Cured 3 days @ 40 deg F – Wet Concrete		3,500 psi min.	3,500 psi min.
Cured 1 day @ 77 deg F – Dry Concrete		5,000 psi min.	5,000 psi min.
Cured 3 days @ 77 deg plus or minus 3 deg F		5,000 psi min.	5,000 psi min.
*Cure test specimens so that peak exothermic temperature of resin does not exceed 100 degrees F. Note: See referenced specifications for preparation method of test specimens.			

2.03 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in place and to resist pressures preventing leakage during injection.

B. Capable of removal after injection resin has cured.

2.04 ACID FLUSHING SOLUTION

A. Pre-mixed solution of food grade phosphoric acid diluted to a 5 percent plus or minus 0.5 percent of the volume of the bottle.

2.05 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

2.06 SAMPLE BOTTLE

A. Five-inch natural wide mouth HDPE bottle or 4-ounce clear PVC cylinder bottle; supplied with caps.

2.07 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of epoxy resin.

B. Pot Life Test:

1. Condition Component A and Component B to required temperature.
2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
3. Mix components for 60 seconds using non-metallic stirring instrument. Scrape sides and bottom of cup periodically.
4. Probe mixture once with non-metallic stirring instrument every 30 seconds, starting 2 minutes prior to minimum specified pot life.
5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.

C. Slant Shear Test: Prepare specimens and perform tests in accordance with ASTM C882.

PART 3 EXECUTION

3.01 GENERAL

A. Unless permitted otherwise, structurally repair cracks or joints listed below:

1. Cracks considered to be defective as defined in Section 03 30 00, Cast-in-Place Concrete.

B. Structurally repair cracks or joints in existing concrete structures where shown on Drawings.

C. Do not proceed with injection work until submittals have been reviewed and approved by Engineer.

D. Perform cracks or joints injection work after removing defective surface materials and after performing surface preparation, but prior to applying surface repair material unless otherwise noted. See Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces, and Section 03 01 33, Repair of Horizontal Concrete Surfaces, for concrete surface repair system.

E. Width of cracks may vary along length and through thickness of concrete section.

F. Remove all excess, unused epoxy resin materials on concrete surfaces exposed to view prior to end of Work.

3.02 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two epoxy resin components and inject mixture into cracks or joints.

B. Pumps:

1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
3. Capable of immediate compensation for changes in resins.
4. Do not use batch mix pumps.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed epoxy resin at pressures in accordance with epoxy resin manufacturer's printed instruction and able to maintain pressure.

D. Automatic Shutoff Control: Provide sensors on both Component A and Component B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: Maintain epoxy resin manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.

F. Ratio/Pressure Check Device:

1. Two independent valve nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.03 PREPARATION

A. Free cracks or joints from loose matter, dirt, laitance, oil, grease, efflorescence, salt, and other contaminants.

B. Clean cracks or joints in accordance with epoxy resin manufacturer's instructions.

C. Clean surfaces adjacent to cracks or joints from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instruction.

D. Do not use acids and corrosives for cleaning, other than those specified herein unless neutralized prior to injecting epoxy resin.

E. During installation and curing of materials, if ambient temperature is expected to drop below manufacturer's recommended minimum temperature, provide enclosures and heat as required.

F. Provide work platforms as required.

G. Dry out cracks or joints if required by manufacturer's instructions.

3.04 APPLICATION

A. All liquid is to be removed from hydraulic structure prior to commencing with epoxy injection, unless approved otherwise.

B. Entry Ports:

1. Establish openings for epoxy resin entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow epoxy resin to penetrate to the full thickness of the member.
3. Drill injection holes at an angle between 45 degrees and 60 degrees from surface of concrete and perpendicular to alignment of cracks or joints to intersect crack or joint at midpoint of concrete section, and intersect joints at midpoint between waterstop and interior concrete surface, except as noted otherwise.
4. Locate drill holes on alternate sides of crack or joint where possible, unless orientation of crack or joint is known or has been verified by non-destructive testing techniques or core drilling.
5. Drill Hole Spacing: Do not to exceed concrete thicknesses or 12 inches maximum, except as noted otherwise.
6. Adjust location and angle of drill holes to suit orientation of crack or joint and at commencement of drilling holes for injection and at beginning of each subsequent shift.

7. Take measures to prevent drilling holes for injection too shallow or too deep or damaging existing waterstop in joints.
8. Remove dust and debris in drill holes and on surface of structure resulting from drilling operation, by flushing with water prior to installing the injection packers or ports.
9. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
    a. Cracks or joints extend entirely through concrete element.
    b. Backfill of walls on one side.
    c. Slab-on-grade.
    d. Difficult to excavate behind wall to seal both surfaces of crack.
10. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks and joints.

C. Acid Flushing of Cracks and Joints:

1. Flush cracks and joints with acid flushing solution in accordance with manufacturer's printed instructions. at high pressure or resin injection pressure. Apply acid flushing solution for a sufficient duration to permit solution to penetrate full depth and length of cracks and joints or to waterstop in joints.
2. Following acid flushing, flush cracks and joints with copious quantities of potable water in accordance with manufacturer's printed instructions at a pressure of 1,000 psi, or resin injection pressure, whichever is greater until no evidence of acid flushing solution is visible in flush water.
3. Submit in-field health and safety plan for acid flushing operation. As a minimum, identify worker conducting acid flushing by wearing a reflective safety vest and signs indicating "Acid Flushing". Also, clearly identify Work area where acid flushing is underway by signs and isolate by placing orange pylons or other temporary barrier, and signs indicating "Acid Flushing". As work progresses, move pylons or barriers and signs to maintain a safe zone.

D. Application of Surface Seal along Cracks and Joints:

1. Apply surface seal in accordance with manufacturer's instructions to designated cracks and joints face prior to injection. Seal surface of cracks or joints to contain and prevent escape of injection epoxy.
2. Cure surface seal in accordance with manufacturer's printed instructions before commencing inject work.

E. Epoxy Injection:

1. Ensure zerk coupling is not installed in ports or packers next to the one being injected.
2. Start injection into each crack or joint at lowest elevation entry port or packer along vertical or diagonal crack or joint, and at one end of horizontal crack or joint.
3. Where injection entry ports or packers are used, continue injection at first port or packer until resin begins to flow out of port or packer at next highest elevation. Plug first port or packer and start injection at second port or packer until resin flows from next port or packer.
4. Inject entire crack or joint with same sequence.
5. At no time inject more than 6 feet length of first vertical crack or joint before verifying resin in sample bottle has started to set and cure.
6. Prior to commencing injection work along a horizontal crack or joint in structure when processed using ports or packers with zerk couplings are used, remove zerk couplings from injection ports or packers except for two ports or packers located where injection work will commence. Commence injection work in first two ports or packers. Once clean resin is vented from third injection port or packer, cease injection at first port or packer, and install zerk coupling and commence injection at third port or packer. Repeat process for fourth and subsequent ports or packers until full length of crack or joint has been injected.

F. Finishing:

1. Allow epoxy resin to cure in accordance with manufacturer's instruction after cracks or joints have been completely injected to allow surface seal removal without draining or runback of uncured epoxy resin material from cracks or joints.
2. Remove surface seal and injection packers or ports from cured injection resin along crack.
3. Finish crack or joint faces flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports, packers, drill holes, or damage from removal of surface seal is not acceptable.
5. Grind off protrusions and patch indentations and holes from injection packers and entry ports with a suitable patch material to satisfaction of Engineer.
6. Remove surplus surface seal material splatters and injection resin material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Epoxy Resin Two-component Ratio Tests:

1. Disconnect mixing head and pump two resin components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both resin components.
3. Simultaneously discharge both resin components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two resin component delivery lines to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
   a. Beginning and end of each injection work day.
   b. When injection work stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Bottled Sample Tests:

1. During injection operation, provide at least one sample of mixed epoxy resin for each injection pump per shift per injection work day in a sample bottle.
2. Provide sufficient sample to demonstrate sample material epoxy resin will set and cure correctly.
3. Label each bottled sample with Contractor's name, date, and time sample was taken, and location in structure where sample was taken. Record details of bottle sample tests.

4. Place filled sample bottle upright in a container and allow sample to cure.
5. After sample has been allowed to cure, cut bottled sample open and visually inspect contents to verify that epoxy resin material has completely reacted and cured.
6. Evaluation and Assessment of Test:
    a. Should bottled sample(s) indicate a problem; such as epoxy resin not cured or foreign liquid in sample bottle, take verifying core sample immediately from cracks or joints, where material was used.
    b. Should above-referenced bottle sample(s) and core sample(s) indicate a problem with epoxy resin, arrange to have a Technical Representative of the epoxy resin manufacturer come to Site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
    c. Carry out further investigation work or corrective measures recommended by Technical Representative of epoxy resin manufacturer.

D. Core Sample Tests:

1. Only where required by Engineer.
2. Initial Cores:
    a. 4-inch diameter for full crack depth along cracks or to waterstop in joints taken from Engineer selected locations.
    b. Take three cores in first 100 linear feet of crack repaired and one core sample for each 500 linear feet thereafter.
    c. Label each core with core number, location, and date when core was obtained.
3. Provide suitable containers for storage, curing, and transportation of test specimens.
4. Methods of Testing Cores:
    a. Penetration: Visual examination.
    b. Bond Strength/Compression Test: Concrete failure prior to resin failure.
5. Test Requirements:
    a. Penetration: Per performance requirements.
    b. Bond Strength (Compression Test): Per performance requirements.
6. Evaluation and Acceptance of Tests:
    a. If initial cores pass tests as specified, epoxy resin injection work at area represented by cores will be accepted.
    b. If initial cores fail either by lack of penetration or bond strength, repair Work shall not proceed further until areas represented by cores are reinjected or repaired and retested for acceptance.

c. Obtain verifying core samples, number, and location as selected by Engineer, after rework of areas represented by failed initial cores is complete.

7. Core Hole Repair:
   a. Correct work as result of testing upon notification from Engineer.
   b. Refill initial and verifying core holes with a suitable repair mortar, per Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces, or Section 03 01 33, Repair of Horizontal Concrete Surfaces, tamped and rodded in-place to completely fill for full depth of core hole.
   c. Finish surface to blend with adjacent concrete.

END OF SECTION

SECTION 04 22 00
CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. C33, Standard Specification for Concrete Aggregates.
   d. C90, Standard Specification for Loadbearing Concrete Masonry Units.
   e. C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   f. C144, Standard Specification for Aggregate for Masonry Mortar.
   g. C150, Standard Specification for Portland Cement.
   h. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   i. C270, Standard Specification for Mortar for Unit Masonry.
   j. C404, Standard Specification for Aggregates for Masonry Grout.
   k. C476, Standard Specification for Grout for Masonry.
   l. C618 12 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   m. C744, Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units.
   n. C979, Pigments for Integrally Colored Concrete.
   o. C989, Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
   p. C1314, Standard Test Method for Compressive Strength of Masonry Prisms.
   q. C1403, Standard Test Method for Rate of Water Absorption of Masonry Mortars.
   r. E514/E514M, Standard Test Method for Water Penetration and Leakage through Masonry.
2. The Masonry Society (TMS):
   a. TMS 402; Building Code Requirements for Masonry Structures and Companion Commentaries.
   b. TMS 602; Specification for Masonry Structures.

3. International Code Council (ICC):
    a. International Building Code (IBC).
    b. ICC Evaluation Service (ICC-ES) Reports.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings.
2. Data Sheets:
    a. Horizontal joint reinforcement.
    b. Preformed control joint materials.
    c. Water repellant masonry sealer.
    d. Grout mix design.
    e. Mortar mix design.
    f. Grout sand gradation in accordance with ASTM C404.
3. Samples:
    a. Sample: Three of each type of masonry unit to be used on Project from the proposed manufacturer.
    b. Mortar colors for color selection.

B. Informational Submittals:

1. Method and Location of Placing Grout: High lift or low lift.
2. Mix design test results.
3. Certifications:
    a. Units comply with ASTM C55 and ASTM C90.
    b. Grout test results conform to ASTM C1019.
    c. Grout aggregates conform to requirements of ASTM C33, including nonreactivity.
    d. Mortar sand conform to requirements of ASTM C144.
4. Test results of Project samples from masonry unit manufacturer stating that units comply with ASTM C90. Documentation of material testing shall be less than 1 year old.
5. Test results of proposed grout mix deign stating that units comply with ASTM C1019. Documentation of material testing shall be less than 1 year old.
6. Test reports stating aggregates for mortar meet requirements of ASTM C144.
7. Test reports or letter of certification stating aggregates for grout meet requirements of ASTM C404.
8. Method and materials for removal of efflorescence.
9. Field test results to qualify materials.
    a. Grout tests in accordance with ASTM C1019.

1.03 QUALITY ASSURANCE

A. Mockups:

1. Lay up Sample panel for each type of masonry at Site unless otherwise indicated or approved by the Engineer.
2. Dimensions: Minimum 4 feet high by 4 feet long.
3. Use approved materials and procedures.
4. Leave intact after approval until acceptance of permanent masonry work and then remove at the end of the Project.
5. Approved panels shall serve as basis of color, texture, bond, quality of finished joints, surface applied finishes, and for acceptance of permanent construction.
6. Demonstrate ability to keep insulation and grout isolated and in certain cells during any sequence of placement, and to demonstrate materials will be restricted to cells and bond beams intended to receive insulation and grout. This requirement is not applicable for projects which only include solid grouted masonry.
7. Demonstrate proper use of running bond pattern.
8. Compliance Requirements: For masonry finish and appearance, dimension tolerances, tolerances of construction, joint tolerances, and wall plumb tolerances, comply with the requirements, recommendations, and criteria of the National Concrete Masonry Association (NCMA), ASTM C90, and TMS 602.

B. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Masonry subcontractor, including masonry foreman.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.
   e. Design Structural Engineer.
   f. Project Architect.
2. Schedule and conduct prior to start of masonry construction.
3. Notify Engineer of location and time.
4. Agenda shall include:
   a. High lift and low lift procedures.
   b. Mortar, grout, unit, and reinforcing submittals.
   c. Types and locations of rebar splices.
   d. Joint tooling.
   e. Admixture types, dosage, performance, and redosing at Site.
   f. Mix designs and test of mix.
   g. Placement methods, techniques, equipment, consolidation, and reconsolidation.

h. Protection procedures for environmental conditions.
i. Other specified requirements requiring coordination.

5. Submit conference minutes as specified in Section 01 31 19, Project Meetings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Keep units and mortar/grout cementitious ingredients, including lime, dry.

PART 2 PRODUCTS

2.01 COMPRESSIVE STRENGTH OF MASONRY ASSEMBLAGE

A. Minimum 28-Day Specified Compressive Strength (f'm) of Masonry:

1. Class A (Typical unless noted otherwise): 2,500 psi.
2. Class B: 2,000 psi.
3. Class C: 1,750 psi.

2.02 CONCRETE MASONRY UNITS (CMU)

A. ASTM C90: Medium weight.

1. Net Area Compressive Strength:
   a. Class A: 3,250 psi minimum.
   b. Class B: 2,000 psi minimum.
   c. Class C: 1,750 psi minimum.
   d. In accordance with TMS 602, Table 2.
   e. Water Repellent Admixture:
      1) Structural concrete masonry units in weather exposed exterior wall shall be manufactured with integral liquid polymeric admixture to provide resistance to water penetration.
      2) Manufacturers and Products:
         a) W.R. Grace & Co.; Dry-Block Block Admixture.
         b) BASF Construction Chemicals; Rheopel Plus.
2. Nominal Size: 16 inches long by 8 inches high by thickness shown on Drawings.
3. Color of Units: Natural unless otherwise indicated on the Drawings.
4. Surface Texture: Smooth, unless otherwise indicated on the drawings.

B. General Concrete Masonry Unit (CMU) Requirements:

1. Furnish or cut special shapes for corners, jambs, lintels, and other areas shown or required.
2. Special units shall match color and texture of standard units.

3. Where units are placed so end of unit is exposed, such as at a corner or intersection, exposed end of that block shall have surface to match color and texture of sides of other units.
4. Furnish sound, dry, clean units free of cracks, prior to placing in structure.
5. Vertical Cells to be Grouted: Align to maintain clear, unobstructed continuous vertical cell dimensions in accordance with TMS 602, Table 6.
6. Masonry unit size and shape shall allow for all placement patterns. Use vertical grout dams to prevent materials, such as grout or poured insulation, from escaping from cell being filled to adjacent cells where material is not intended to be placed.

2.03 MORTAR MATERIALS

A. Portland Cement-Lime Mortar:

1. ASTM C270.
2. Cement: ASTM C150, Type I or Type II portland cement.
3. Lime: ASTM C207, Type S hydrated.
4. Aggregates:
   a. Non-reactive in accordance with ASTM C33, Appendix X1.
   b. Mortar: ASTM C144, sand.

B. Mortar Cement Mortar: ASTM C1329.

C. Water: Fresh, clean, and potable.

D. Water Repellent Admixture:

1. ASTM C1403.
2. Mortar for masonry units in weather exposed exterior walls shall include an integral liquid polymeric admixture to provide resistance to water penetration.
3. Manufacturer and Product: BASF Construction Chemicals; Rheopel Plus Mortar Admixture.

E. Manufacturers and Products:

1. W.R. Grace; DRY-BLOCK.
2. Harris Specialty Chemicals.
3. Axim Italcementi Group; Intrapel.
4. BASF Chemical Co.; Rheopel Admixture.

F. Mortar Color Admixture:

1. Meet the requirements of ASTM C979.
2. Manufacturer and Product: Davis Colors, Los Angeles, CA; True Tone Mortar Color.
3. Color shall be natural unless otherwise indicated on the Drawings.

2.04 GROUT MATERIALS

A. Cement: ASTM C150, Type I or Type II portland cement.

B. Fly Ash: Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618.

C. Slag Cement: In accordance with ASTM C989, Grade 100 or Grade 120.

D. Lime: ASTM C207, Type S hydrated.

E. Aggregates:

1. ASTM C404, fine and coarse.
2. Non-reactive in accordance with ASTM C33, Appendix X1.

F. Water: Fresh, clean, and potable.

2.05 REINFORCEMENT

A. Reinforcement: Clean and free from loose rust, scale, and coatings that reduce bond.

B. Deformed Bars: As specified in Section 03 21 00, Steel Reinforcement.

C. Horizontal Joint Reinforcement:

1. Two parallel, ASTM A82/A82M, No. 9 wires, galvanized in accordance with ASTM A153/A153M, weld connected to No. 9 perpendicular diagonal cross wire at 16 inches, maximum, center.
2. Furnish special manufactured corner and wall intersection pieces.
3. Manufacturer: Dayton Superior/Dur-O-Wal, Dayton, OH.

2.06 PREFORMED CONTROL JOINTS

A. Solid rubber cross-shape extrusions as manufactured by:

1. Dayton Superior/Dur-O-Wal Dayton, OH; DA 2001 Control Joint Regular Rubber.
2. Hohmann and Barnard, Inc, Hauppauge, NY; #RS-Standard.

2.07 MORTAR MIXES

A. In accordance with ASTM C270, Type S and TMS 602.

B. Mix Method:

1. Property Method: Minimum average mortar 28-day compressive strength 1,800 psi.

C. Mixing:

1. Machine mix in approved mixers in accordance with ASTM C270.
2. Time addition of approved admixtures in accordance with manufacturer's instructions. Procedure used for adding it to mix shall provide good dispersion.

2.08 GROUT MIXES

A. Compressive Strength Property:

1. Minimum compressive strength at 28 days shall be the greater of the following:
   a. 2,000 psi.
   b. Required compressive strength of the masonry assemblage.

B. Mix Design:

1. Proportions:
   a. Design mix to meet property/strength requirements.
   b. Where fly ash or slag is included in mix, fly ash or slag content shall be a minimum of 25 percent and a maximum of 40 percent of weight of total cementitious materials.
2. Slump: 8-inch minimum, 11-inch maximum.

C. Mixing:

1. Do not use water reducers, air entrainment, plasticizing, high-range water reducers, or other non-specified admixtures in grout mixes.
2. Transit-Mixed Grout: Meet requirements of ASTM C476.
3. For high lift grouting, add approved grout expansion admixture in accordance with manufacturer's recommendations.
4. Fluid consistency suitable for placing without segregation with a slump of 8 inches to 11 inches.

2.09 WATER REPELLENT MASONRY SEALER

A. Characteristics:

1. Water-based blend of silanes and siloxanes.
2. VOC compliant.

B. Performance Requirements:

1. Water Absorption: 95 percent reduction in weight gain when tested in accordance with ASTM C140.
2. Water Repellency: 99 percent reduction in weight gain when tested in accordance with ASTM E514.

C. Manufacturers and Products:

1. W. R. Grace & Co.; Infiniseal DB Sealer.
2. BASF Construction Chemicals; Enviroseal PBT.

PART 3 EXECUTION

3.01 GENERAL

A. Meet requirements of IBC, Chapter 21 and TMS 602 except as modified in this section.

B. Moisture Protection:

1. Keep units dry while stored on Site.
2. Do not wet units prior to laying.

C. Provide measures to prevent moisture from entering incomplete walls and open cells.

D. Cold Weather: Meet requirements of TMS 602 Section “Cold Weather Construction”.

E. Hot Weather: Meet requirements of TMS 602 Section “Hot Weather Construction”.

F. After construction during cold weather, maintain newly constructed masonry temperature above 32 degrees F for a minimum of 24 hours using TMC or other approved cold weather methods.

G. After construction and during hot weather, fog spray newly constructed masonry in accordance with TMS 602 hot weather construction requirements.

3.02 PREPARATION

A. Concrete Foundations: Meet tolerance requirements of ACI 117 prior to starting any masonry work.

B. Prepare surface contact area of foundation concrete for initial mortar placement by removing laitance, loose aggregate, and other materials, and anything that would prevent mortar from bonding to foundation.

C. Patch or grind out-of-tolerance foundation surfaces to receive mortar prior to starting masonry work.

D. Clean reinforcement dowels and projecting embeds by removing laitance, spillage, or items that will adversely affect grout bond.

E. Prevent surface damage to foundation concrete that will be exposed to view outside of contact area.

3.03 LAYING MASONRY UNITS

A. General:

1. Finish Tolerances (Measured on Interior Surfaces): Meet requirements of “Site Tolerance” requirements of Part 3, Execution, of the TMS 602.
2. Place units with chipped edges or corners such that chipped area is not exposed to view.

B. Wall Units:

1. General:
   a. If necessary to move a unit after once set in-place, remove from wall, clean, and set in fresh mortar.
   b. Toothing of masonry units is not permitted.
2. Running Bond:
   a. Unless otherwise shown, lay up walls in straight, level, and uniform courses using a running bond pattern.
   b. Place units for continuous vertical cells and mortar joints to prevent materials, such as grout and poured insulation, from escaping from cell being filled to adjacent cells where material is not intended to be placed.
   c. Corners: Lay standard masonry bond for overlapping units and grout solid.
   d. Intersecting Walls: Half unit appearance shall not extend and be visible on exterior side of intersecting wall. Provide hooked corner bars in bond beam units and joint reinforcement as shown on Drawings.

3. Stack Bond: Provide only where specifically indicated on Drawings. Lay up masonry units in straight, uniform courses with vertical joints aligned and plumb.
4. Glazed Concrete Masonry Units:
    a. Single-faced units may be installed through wall where walls or partitions are shown to have glazed masonry unit finish on one side only.
    b. Use facing for dimensional and plane reference in installation.
    c. Where glazed masonry unit finish is indicated on both sides of a wall or partition, install coved bases of two-unit construction or two-faced units through the wall.
    d. Install coved bases flush with finished surfaces above, except as otherwise specified.
5. Special Shapes:
    a. Provide and place such special units as corner block, doorjamb block, lintel block fillers, and similar blocks as may be required.
    b. Use required shapes and sizes to work to corners and openings, maintaining proper bond throughout wall.

3.04 BUILT-IN ITEMS

A. Position door frames, windows, vents, louvers, and other items to be built in wall, and construct wall around them.

B. Install masonry anchors to secure items to wall.

C. Fill spaces around items with grout except use mortar at mortar joints.

D. Do not place electrical, instrumentation, or water conduits in a cell containing parallel reinforcement, unless approved in writing by Engineer. Additionally, pipes, sleeves, and conduits shall meet requirements of TMS 402 and TMS 602 construction requirements.

3.05 MORTAR JOINTS

A. General:

1. Meet masonry erection requirements of TMS 602, Part 3, Execution, 3.3B.
2. As units are laid, remove excess mortar from grout space of cells to be filled. Final grout space, including any remaining mortar projections, shall be as required by TMS 602 Table 6, Grout Space Requirements.
3. Place mortar before initial setting of cement takes place. Retemper only as required for it to remain plastic. Retempering of colored mortar is not allowed.

4. Remove mortar containing water repellent admixture from face of masonry before it sets.

B. Exposed Joints:

1. Tool joints exposed to view after final construction, unless otherwise noted or shown.
2. Cut joints flush and as mortar takes its initial set; tool to provide a concave joint unless otherwise indicated.
3. Perform tooling with tool that compacts mortar, pressing excess mortar out.
4. Perform tooling when mortar is partially set, but still sufficiently plastic to bond rather than dragging it out.
5. Rake out joints that are not tight at time of tooling, point, and then tool.
6. Rake and tool joints at split-face surfaces, interior and exterior.

C. Concealed Joints: Strike flush with no further treatment required.

D. Glazed Concrete Masonry Units:

1. Rake mortar from joints to depth of 1/4 inch.
2. Fill joints flush with glazed surface using Type 1, silicone, sealant as specified in Section 07 92 00, Joint Sealants, color as indicated on the Drawings or selected by the Engineer.
3. Tool joints slightly concave.

3.06 CONTROL JOINTS

A. Preformed Control Joints:

1. Omit mortar from vertical joints.
2. Place in units fabricated to receive rubber control joint material as wall is built.
3. After wall is grouted, cured, and cleaned, install backing rod and sealant as specified in Section 07 92 00, Joint Sealants.
4. Place and tool sealant to match depth of typical joint.

3.07 REINFORCING

A. Foundation Dowels:

1. Locate first foundation dowel at end of wall in center of first cell; typically 4 inches from end of wall.
2. Locate at each side of control joints and openings and below beam and joist seats, and then locate at maximum required spacing between these bars.

3. Size, number, and location of foundation dowels shall match all typical and additional vertical wall reinforcing, unless otherwise noted.
4. When foundation dowel does not line up with vertical core, do not slope more than 1 horizontal to 6 vertical to bring it into alignment.

B. Vertical Reinforcing:

1. Use deformed bars.
2. Hold in position near ends of bars by wire ties to dowels or by reinforcing positioners.
3. For high lift grouting, hold in position at maximum intervals of 160 bar diameters by reinforcing positioners.
4. Lap reinforcing bars as shown or approved.
5. Wire tie splices together.
6. Minimum bar clearance from formed surfaces and from parallel bars in same grout space:
   a. 1/2-inch from masonry for coarse grout.
   b. 1/4-inch from masonry for fine grout.

C. Horizontal Reinforcing:

1. Use deformed bars.
2. Lay on webs of bond beam units and place as wall is built. Increase web depth to ensure 1/2-inch cover over top of rebar.
3. Lap reinforcing bars where spliced and wire tie together.
4. Minimum bar clearance from formed surfaces and from parallel bars in same grout space:
   a. 1/2-inch from masonry for coarse grout.
   b. 1/4-inch from masonry for fine grout.
5. Terminate reinforcing bars 2 inches clear from control joints except horizontal bars at roof and floor courses shall be continuous through joints.

D. Horizontal Joint Reinforcement:

1. Use where indicated on Drawings.
2. Provide in addition to typical, deformed horizontal reinforcing steel.
3. Space maximum 16 inches apart, vertically.
4. Lap ends 16 inches minimum.
5. Terminate reinforcing 2 inches clear from control joints except reinforcement at roof and floor courses shall be continuous through joints.
6. Use manufactured corner and other wall intersection pieces.

3.08 MORTAR PRODUCTION

A. Mix bulk materials in accordance with TMS 602.

B. Mix prebagged materials with water to produce a workable consistency.

C. Remix or retemper to maintain workability. Discard mortar that has begun to stiffen or is not used within 2-1/2 hours after initial mixing.

3.09 GROUT PLACEMENT

A. Do not mix, convey, or place with equipment constructed of aluminum.

B. Secure vertical and horizontal reinforcement, ties, bolts, anchors, and other required embedments in place; inspect and verify before placing grout.

C. Grout beams over openings in one continuous operation.

D. Maintain vertical alignment as required to satisfy grout space requirements in accordance with TMS 602, Table 6.

E. Place grout within 1-1/2 hours of addition of water to mix.

F. Use reinforcing positioners to secure vertical reinforcement.

G. Grouting Requirements:

1. Solid grout walls unless indicated otherwise on the Drawings.
2. For multi-wythe construction, space vertical grout barriers maximum 30 feet horizontally, extending full height of wall.
3. Slump: 8 inches to 11 inches.
4. Do not start grouting until wall mortar has cured for 24 hours, minimum.
5. Fully embed horizontal steel with grout in an uninterrupted pour.
6. Do not construct wall more than one course above top of grout pour prior to placing grout.
7. Partial Grouting Requirements:
    a. Fill cells containing reinforcing steel, anchor bolts, and other embedded items as shown with grout.
    b. Construct cells to be filled to confine grout within cell.
    c. Cover tops of unfilled vertical cells under a bond beam with metal lath to confine grout fill to bond beam section.
    d. Form horizontal construction joints between pours by stopping grout pour 1-1/2 inches below a mortar joint, except at a bond beam; stop pour 1/2 inch below top of masonry unit.

H. Partial Grouting with Insulation Fill:

1. Where cells of masonry units are to receive masonry fill insulation in some cells and to receive grout in some cells, provide continuous mortar on block webs on each side of cells to be filled with grout to ensure insulation will not enter grout cells.
2. Where bond beams are required with masonry fill insulation and grout, limit pours to less than 6 feet in height.

I. Vibration:

1. Use internal “pencil” type, low energy vibrator to thoroughly consolidate grout and reduce amount of air voids. Do not use concrete vibrators.
2. After initial water loss and settlement has occurred, but before it has taken any set, reconsolidate grout.
3. Waiting period for reconsolidation will vary depending upon weather conditions and block absorption rates, but under “normal” weather conditions with average masonry units the waiting period should be between 30 minutes and 60 minutes.

J. Cleanouts:

1. Construct in accordance with TMS 602.
2. Provide for grout pours heights over 5 feet 4 inches.
3. Provide of sufficient size to permit cleaning of cell, positioning of reinforcing, and inspection at bottom of every vertical cell containing reinforcing and maximum of 32 inches on center.
4. Location: Concealed from view after final construction, unless otherwise approved by Engineer.
5. After wall has been inspected and approved and prior to grouting, cap cleanouts in a manner that will seal them from grout leakage and provide a flush finish.

3.10 WATER REPELLENT MASONRY SEALER

A. Remove efflorescence prior to applying water repellents. Dispose of waste generated.

B. Apply to exposed exterior concrete masonry walls.

C. Repoint loose, cracked, or disintegrating mortar at least 7 days prior to application. Ensure joint sealants and caulking are fully cured and wall surfaces are clean, dry, and free of chemical cleaners, efflorescence, dirt, oils, mortar smears, and other surface contaminants.

D. Follow manufacturer’s recommendations for weather conditions during application.

E. Test a 5-foot by 5-foot wall area to ensure proper coverage, desired water repellency properties, and desired surface appearance when sealer is fully dried.

F. Apply with spray, brush, or roller following manufacturer's recommendations, at a coverage rate of 50 square feet to 150 square feet per gallon, as determined by testing. Use two-coat application where recommended by manufacturer.

3.11 FIELD QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements as indicated on the General Structural Notes on the Drawings.

B. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

C. Provide adequate facilities for safe storage and proper curing of masonry, mortar, and grout samples as applicable, onsite for first 24 hours, and for additional time as may be required before transporting to test lab.

D. Masonry Testing:

1. Masonry shall be tested by independent testing agency retained by the Contractor.
2. Masonry strength shall be determined using unit strength method as shown.
3. Unit Strength Method:
    a. Method and frequency for mortar, grout, and masonry unit sampling and testing shall be as shown.
    b. Provide masonry units for test samples required.

E. Corrective Action:

1. If compressive strength tests made prior to construction of permanent structure fail to meet Specifications, adjustments shall be made to mix designs for mortar, or grout, or both, as needed to produce specified strength.
2. If strength tests performed on materials representative of in-place construction fail to meet Specifications, prisms or cores shall be cut from constructed walls in sufficient locations to adequately determine strength in accordance with TMS 602.
3. Water Repellent Performance Test: Masonry using concrete masonry units and mortar with integral water repellent additives, and water repellent masonry sealer, shall achieve a Class E rating when evaluated in accordance with ASTM E514, with the test extended to 72 hours.

3.12 CLEANING

A. Immediately after completion of grouting, clean masonry surfaces of excess mortar, grout spillage, scum, stains, dirt, and other foreign substances using clean water and fiber brushes.

B. Clean walls not requiring painting or sealing so there are no visible stains.

3.13 PROTECTION OF INSTALLED WORK

A. Do not allow grout and mortar stains to dry on face of exposed masonry.

B. Protect tops of walls at all times. Cover tops of walls with waterproof paper when rain or snow is imminent and when the Work is discontinued.

C. Adequately brace walls until walls and roof are completed.

D. Provide sufficient bracing to protect walls against damage from elements, including wind and snow.

E. Protect masonry against freezing for minimum 72 hours after being laid.

F. Protect masonry from damage until final acceptance of the Work. Damaged units will not be accepted.

END OF SECTION

SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 318, Building Code Requirements for Structural Concrete.
   b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
   c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM):
   a. A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A143, Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   c. A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   d. A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   e. A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
   f. A380, Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   g. A385, Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
   h. A563, Specification for Carbon and Alloy Steel Nuts.
   i. A780, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   j. A967, Specification for Chemical Passivation Treatments for Stainless Steel Parts.
   k. E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
   l. F436, Specification for Hardened Steel Washers.
   m. F468, Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
   n. F568M, Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.

o. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
p. F594, Specification for Stainless Steel Nuts.
q. F1554, Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
6. International Code Council Evaluation Service (ICC-ES):
   a. Evaluation Reports for Concrete and Masonry Anchors.
   b. AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
   c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
   d. AC106, Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
   e. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
   f. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.
7. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
8. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.

C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete and Masonry Anchors:
   a. Manufacturer's product description and installation instructions.
   b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
   c. Adhesive Anchor Installer Certification.
2. Passivation method for stainless steel members.
3. Hot-Dip Galvanizing: Certificate of Compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program or equivalent.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package stainless steel items in a manner to provide protection from carbon impregnation.

B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.
5. Acceptable for use in potable water structures by EPA and local health agencies or NSF 61 for when exposed to potable water.

B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
   a. Hilti, Inc., Plano, TX; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
   b. DeWalt/Powers Fasteners, Towson, MD; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-3037).

C. Undercut Anchors:

1. Manufacturers and Products:
   a. Mitek Inc., Chesterfield, MO; DUC Undercut Anchor (ESR-1970).
   b. Hilti, Inc., Plano, TX; HDA Undercut Anchor (ESR-1546).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; TCA Self-Undercutting Anchors (ESR-2705).
   d. DeWalt, Towson, Maryland; Atomic+ Undercut Anchor (ESR-3067).

D. Self-Tapping Concrete Screw Anchors:

1. Manufacturers and Products:
   a. DeWalt/Powers Fasteners, Towson, MD; Snake+ Flush Mount Screw Anchor (ESR-2272).
   b. Hilti, Inc., Plano, TX; KH-EZ Screw Anchor (ESR-3027).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).

E. Adhesive Anchors:

1. Threaded Rod:
   a. Diameter as shown on Drawings.
   b. Length as required to provide minimum depth of embedment indicated and thread projection required.
   c. Clean and free of grease, oil, or other deleterious material.
2. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
3. Packaging and Storage:
   a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
   b. Store adhesive on pallets or shelving in a covered storage area.

c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
d. Dispose of When:
1) Shelf life has expired.
2) Stored other than in accordance with manufacturer's instructions.

4. Manufacturers and Products:
a. Hilti, Inc., Plano, TX; HIT Doweling Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 (ESR-3187).
b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508), or AT-XP Adhesive Anchors (IAPMO UES-263).
c. DeWalt/Powers Fasteners, Towson, MD; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

F. Adhesive Threaded Inserts:

1. Type 316 stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Plano, TX, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.

2.03 POST-INSTALLED MASONRY ANCHORS

A. General: AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of section.

B. Current ICC Evaluation Report indicating acceptance for anchors at structural applications in masonry.

C. Manufacturers and Products:

1. Hilti, Inc., Plano, TX; Kwik-Bolt-3 (KB-3) (ESR-1385), for grout-filled masonry, HIT-HY 270 (ESR-4143) for grout filled CMU, hollow CMU, or hollow (ungrouted) brick masonry.
2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU and hollow CMU.
3. DeWalt/Powers Fasteners, Towson, MD; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Screw-Bolt+ (ESR-4042) for grout-filled masonry.

PART 3 EXECUTION

3.01 CONCRETE AND MASONRY ANCHORS

A. Begin installation only after concrete or masonry to receive anchors has attained design strength.

B. Locate existing reinforcing with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing.

C. Install in accordance with written manufacturer's instructions.

D. Provide minimum embedment, edge distance, and spacing as indicated on Drawings.

E. Use only drill type and bit type and diameter recommended by anchor manufacturer.

F. Clean hole of debris and dust per manufacturer's requirements.

G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

H. Adhesive Anchors:

1. Unless otherwise approved by Engineer and adhesive manufacturer:
   a. Do not install adhesive anchors when temperature of concrete or masonry is below 40 degrees F or above 100 degrees F.
   b. Do not install prior to concrete attaining an age of 21 days.
   c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
   d. Do not disturb anchor during recommended curing time.
   e. Do not exceed maximum torque as specified in manufacturer's instructions.
2. For hollow-unit masonry, install screen tube in accordance with manufacturer's instructions.

I. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without Engineer's prior approval unless specifically shown on Drawings.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

B. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

C. Proof Loading:

1. To be performed where continuous inspection of anchors is required.
2. Proof loading of adhesive anchors to be performed only after adhesive has achieved proper cure per manufacturer's requirements.
3. Testing will be conducted on minimum of 10 percent of installed anchors, with a minimum of two tension tests.
4. Testing will be conducted in accordance with ASTM E488 and as follows:
    a. Performance of a static tension test of each test anchor.
    b. Test apparatus reaction base shall not interfere with bond failure of anchor but shall preclude a pullout cone failure.
    c. Each test anchor to be tested at a proof load equal to the lesser of 80 percent of the yield strength of the anchor or 50 percent of calculated ultimate load based on adhesive bond strength or as directed by Engineer.
    d. Test load to be maintained for a minimum of 30 seconds without visible signs of movement of anchor or drop in gauge reading.
5. Failure of anchor or failure within base material will cause anchor to be rejected. For each rejected anchor, test two additional anchors. Rejected anchors shall be replaced as approved by Engineer.

3.03 MANUFACTURER'S SERVICES

A. Adhesive and Mechanical Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment).		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors, except undercut anchors for sustained tension loading.	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
2. Anchors in Grout-Filled Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel anchors	

Service Use and Location	Product	Remarks
3. Anchors in Hollow Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Adhesive anchors shall be installed with screen tubes.
Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Adhesive anchors shall be installed with screen tubes.
4. All Others		
All service uses and locations	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on all stainless steel threads.

C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05 05 23
STRUCTURAL WELDING

PART 1 GENERAL

1.01 GENERAL

A. Requirements of this section are applicable for all welding except for welding of steel pipe which shall be in accordance with Section 33 05 01.01, Welded Steel Pipe and Fittings.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. BPVC SEC V, Nondestructive Examination.
   b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
4. American Welding Society (AWS):
   a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   b. A3.0, Standard Welding Terms and Definitions.
   c. D1.1/D1.1M, Structural Welding Code - Steel.
   d. D1.8/D1.8M, Structural Welding Code - Seismic Supplement.
   e. D1.2/D1.2M, Structural Welding Code - Aluminum.
   f. D1.3/1.3M, Structural Welding Code - Sheet Steel.
   g. D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
   h. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
   i. QC1, Standard for AWS Certification of Welding Inspectors.

1.03 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

1. Contractor's Welding Inspector: Contractor's CWI acts for, and on behalf of, the Contractor for all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection, NDT, and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes.

2. Verification Inspector: CWI who acts on behalf of the Owner. This type of independent inspection and testing is the prerogative of the Owner, who may perform this function, or waive independent verification inspection if it is not required by the building official and building code.

C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. RT: Radiographic Testing.

J. UT: Ultrasonic Testing.

K. VT: Visual Inspection/Testing.

L. WPQ: Welder/Welding Operator Performance Qualification Record.

M. WPS: Welding Procedure Specification.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop and field WPSs and PQRs.
   b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
   c. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
      1) Show on Shop Drawings, or on a weld map, complete information regarding base metal specification designation, location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tails of combined welding and NDE symbols as indicated in AWS A2.4.
      2) Clearly distinguish between shop and field welds.

3) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
4) Welding and NDE Symbols: In accordance with AWS A2.4.
5) Welding Terms and Definitions: In accordance with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency personnel credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms in referenced welding codes.

1.05 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex M Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex M Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require prior approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.06 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verifying conformance of specified job material and proper storage.
2. Monitoring conformance with approved WPS.
3. Monitoring conformance of WPQ.
4. Inspecting weld joint fit-up and performing in-process inspection.
5. Providing 100 percent visual inspection of welds.
6. Coordinating with nondestructive testing personnel and reviewing NDE test results.
7. Maintaining records and preparing reports documenting that results of CWI VT and subsequent NDE testing comply with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Quality Control Inspection:

1. All Welds: 100 percent VT by Contractor's CWI.
2. Acceptance Criteria:
   a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 9.25.
   b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
   c. Stud Connections: AWS D1.1/D1.1M, Paragraph 7.8.1.

B. Nondestructive Testing Requirements:

1. NDT frequency shall be as specified below, as required by referenced welding codes, or as specified in the attached table. In case there is a conflict, the higher frequency level of NDT shall apply.
   a. Nontubular Connections:
      1) CJP Butt Joint Groove Welds: 10 percent random RT Use UT for CJP butt joint groove welds that cannot be readily radiographed.
      2) All Other CJP Groove Welds: 10 percent random UT.
      3) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
   b. Tubular Connections:
      1) CJP butt joint groove welds made from one side without backing: 100 percent RT or UT in accordance with AWS D1.1/D1.1M, Paragraph 9.26.2 requirements.
      2) CJP Butt Joint Groove Welds made without backing or back-gouging: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.
      3) All Other CJP Groove Welds: 10 percent random.
      4) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
2. NDT Procedures and Acceptance Criteria:
   a. Nontubular Connections:
      1) RT: Perform in accordance with AWS D1.1/D1.1M, Clause 6, Part E. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 6.12.1.
      2) UT: Perform in accordance with AWS D1.1/D1.1M, Clause 6, Part F. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 6.13.1.
      3) PT and MT:
         a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.14.4 and Paragraph 6.14.5.
         b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
   b. Tubular Connections:
      1) RT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 9, Paragraph 9.28 and Paragraph 9.29.
      2) UT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 9, Paragraph 9.27.

3) PT and MT:
   a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.14.4 and Paragraph 6.14.5.
   b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 9.25.

3.03 FIELD QUALITY CONTROL

A. CWI shall be present whenever field welding is performed. CWI shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job material and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor conformance of WPQ.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds in accordance with Subparagraph Quality Control Inspection.
6. Supervise nondestructive testing personnel and evaluating test results.
7. Maintain records and prepare report confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal has been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Welding and Nondestructive Testing Table.

END OF SECTION

WELDING AND NONDESTRUCTIVE TESTING						
Specification Section	Governing Welding Codes or Standards	Submit WPS	Submit WPQ	Onsite CWI Req'd	Submit Written NDT Procedure Specifications	NDT Requirements
03 21 00 Steel Reinforcement	AWS D1.4/D1.4M, Structural Welding Code - Reinforcing Steel	Yes	Yes	Yes	Yes	100% VT and 100% MT of all rebar splices; also see Section 03 21 00
05 12 00 Structural Steel Framing	AWS D1.1/D1.1M, Structural Welding Code - Steel	Yes	Yes	Yes	Yes	100% VT and 10% UT or RT of all groove-and-butt joint welds; 10% MT of all fillet welds; also see Section 05 12 00
05 31 00 Steel Decking	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.3/D1.3M, Structural Welding Code - Sheet Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 31 00
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum or AWS D1.6/D1.6M, Structural Welding Code - Stainless Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 50 00
05 52 19 Steel Railings	AWS D1.1/D1.1M, Structural Welding Code - Steel	No	No	No	No	100% VT; also see Section 05 52 19, Steel Railings
05 53 00 Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 53 00

SECTION 05 12 00
STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Galvanizers Association (AGA): Quality Assurance Manual.
2. American Institute of Steel Construction (AISC):
   a. 201, Certification Program for Structural Steel Fabricators.
   b. 206, Certification Program for Structural Steel Erectors—Standard for Structural Steel Erectors.
   c. 303, Code of Standard Practices for Steel Buildings and Bridges.
   d. 325, Steel Construction Manual.
   e. 326, Detailing for Steel Construction.
   f. 341, Seismic Provisions for Structural Steel Buildings.
   g. 360, Specification for Structural Steel Buildings.
   h. 420, Certification Standard for Shop Application of Complex Protective Coating Systems.
3. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code—Steel.
   b. D1.8/D1.8M, Structural Welding Code—Seismic Supplement.
4. ASTM International (ASTM):
   a. A6/A6M, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   b. A36/A36M, Standard Specification for Carbon Structural Steel.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   d. A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   e. A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   f. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   g. A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   h. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

i. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
j. A490, Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
k. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
l. A563, Standard Specification for Carbons and Alloy Steel Nuts.
m. A572/A572M, Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel.
n. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
o. A992/A992M, Standard Specification for Structural Steel Shapes.
p. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
q. A1085/A1085M, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
r. F436, Standard Specification for Hardened Steel Washers.
s. F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
t. F1136, Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
u. F1852, Standard Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
v. F2280, Standard Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
w. F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

5. Occupational Safety and Health Administration (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawing details showing:
   a. Erection plans.
   b. Members, including piece numbers, sizes, grades, dimensions, cambers, and connection details.
   c. Anchor bolt layouts.

d. Hardened washer details.
e. Connection material specifications.
f. Indicate type, size, and length of bolts.
g. Joint details for complete penetration welds.
h. Indicate welds by standard AWS symbols, distinguishing between shop and field welds and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.

2. Product specifications, including primer and other coatings.
3. Identify pretensioned and slip-critical high strength bolted connections.
4. Locations of Class A, or higher, faying surfaces.
5. Weld access hole dimensions, surface profile, and finish requirements.
6. Location of demand critical shop welds.
7. Locations and dimensions of protected zones.
8. Gusset plates drawn to scale when they are detailed to accommodate inelastic rotation.
9. Nondestructive testing (NDT) where performed by the fabricator.
10. Welding requirements as specified in AISC 341 Appendix W, Section W2.2.

B. Informational Submittals:

1. Name and address of manufacturer(s).
2. AISC Quality Certification: AISC certificate showing name and address of certified firm, effective date, and category of certification; or, for erectors, documentation of similar project experience to include project name, location, date of completion, and name and phone number of owner's contact person.
3. Mill Certificates of tests made in accordance with ASTM A6/A6M.
4. Manufacturers' testing procedures and standards.
5. Preparation and installation or application instructions, as appropriate.
6. Proposed method to resolve misalignment between anchor bolts and bolt holes in steel members.
7. High-Strength Bolts:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that products meet specified chemical and mechanical requirements.
   b. Manufacturer's inspection test report results for production lot(s) furnished to include:
      1) Tensile strength.
      2) Yield strength.
      3) Reduction of area.
      4) Elongation and hardness.

c. Certified Mill Test Reports for Bolts and Nuts:
   1) Name and address of manufacturer.
   2) Bolts correctly marked.
   3) Marked bolts and nuts used in required mill tests and manufacturer's inspection tests.

8. Direct Tension Indicators (DTIs): Manufacturer's test report meeting requirements of ASTM F959.
9. Twist-Off-Type Tension-Control (TC) Bolts: Manufacturer's test report meeting requirements of ASTM F1852
10. Welding Procedures, Qualifications, and Inspection Reports: As specified in Section 05 05 23, Structural Welding.
11. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.
12. Nondestructive Testing (NDT) report.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Welding qualifications as specified in Section 05 05 23, Structural Welding.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of AGA's Quality Assurance Manual.

B. Certifications:

1. AISC Quality Certification for Fabricator: A fabricator who participates in the AISC Certification program and is designated an AISC certified plant, Category STD.
2. Mill identification marks, heat number, size of section, and length in accordance with ASTM A6/A6M.

C. Certificate of Compliance: Fabricator's certified document stating that the materials supplied and work performed by the fabricator are in accordance with the contractor documents.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Load structural members in such a manner that they will be transported and unloaded without damage to coatings and without being excessively stressed, deformed, or otherwise damaged.

B. Storage:

1. Store materials to permit easy access for inspection and identification. Store in a dry area and keep steel members off

ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

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

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

a. Fasteners may be repackaged provided testing and inspecting agency observes repackaging and sealing of containers.

b. Clean and lubricate bolts and nuts that become dry or rusty before use.

c. Comply with manufacturer's written recommendations for cleaning and lubricating fasteners and for retesting fasteners after lubrication.

C. Handle materials to avoid distortion or damage to members or supporting structures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Rolled Plates, Shapes except W-Shapes and Bars: ASTM A36/A36M, unless indicated otherwise.

B. W-Shapes: ASTM A992/A992M, unless indicated otherwise on Drawings.

C. Steel Pipe: ASTM A53/A53M, Grade B.

D. Round Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 46 ksi).

E. Square and Rectangular Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 50 ksi).

2.02 FASTENERS

A. Anchor Bolts: As specified in Section 05 50 00, Metal Fabrications.

B. Post-Installed Anchors: As specified in Section 05 05 19, Post-Installed Anchors.

C. High-Strength Bolts:

1. ASTM A325, Type 1, hot-dip galvanized.
2. Bolt Length and Thread Length: As required for connection type shown, with hardened washers as required.

D. Nuts: ASTM A563, type to match bolt type and finish.

E. Hardened Steel Flat and Beveled Washers: ASTM F436, type to match bolt finish.

2.03 ANCILLARY MATERIALS

A. Surface Preparation and Primer: As specified in Section 09 90 00, Painting and Coating.

B. Grout: As specified in Section 03 62 00, Grouting.

2.04 FABRICATION

A. General:

1. Fabricate as shown and in accordance with AISC 360 and AISC 303.
2. Mark and match mark materials for field assembly.
3. Complete assembly, including bolting and welding of units, before start of finishing operations.
4. Fabricate to agree with field measurements.
5. Fabricate beams with rolling camber up.

B. Connections:

1. Shop Connections: Weld or bolt as shown on Drawings.
2. Meet requirements of AISC 325 for bolted double-angle shear connections, unless indicated otherwise.
3. Meet OSHA requirements for one independent bolt at beams framing in to column web connections.
4. Provide oversized holes for anchor bolts in column baseplate in accordance with AISC 325, unless indicated otherwise.

C. Welded Construction:

1. As specified in Section 05 05 23, Structural Welding.
2. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

D. Interface with Other Work:

1. Holes:
   a. As necessary or as indicated for securing other Work to structural steel framing, and for passage of other Work through steel framing members shall be approved by Engineer.
   b. No flame-cut holes are permitted without prior approval of Engineer.

2. Weld threaded nuts to framing members, and other specialty items to receive other Work.

2.05 FINISHES

A. Shop Paint Primer:

1. Surface Preparation and painting as specified in Section 09 90 00, Painting and Coating.
2. Do not shop prime the following surfaces, unless indicated otherwise:
   a. Within 2 inches of field-welded connections.
   b. Steel members to be completely encased in reinforced concrete or coated with cementitious fireproofing.
3. Apply shop primer to top flange surfaces of composite steel beams, unless indicated otherwise.

B. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of steel.
2. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
3. Remove, by blast cleaning or other methods, surface contaminants and coatings not removable by normal chemical cleaning process in galvanizing operation.
4. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
5. Hot-dip galvanize ASTM A325 bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop-assemble bolts, nuts, and washers with special lubricant and test in accordance with ASTM A325 and ASTM A563.
6. Mechanically zinc coat ASTM F1852 twist-of-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F1852 and ASTM B695, Class 50.
7. Coat ASTM F2280 twist-off-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F1136.
8. Galvanize components of bolted assemblies separately before assembly.

C. Slip Critical Bolted Connections:

1. Coated Faying Surfaces: Coat faying surfaces of slip critical bolted connections specified or shown with a paint primer with a Class A or Class B coating in accordance with the RCSC Specification for

Structural Joints Using High-Strength Bolts and as specified in Section 09 90 00, Painting and Coating. Protect against overspray by use of masking. Remove inadvertent overspray from the faying surfaces.

2. Galvanized Faying Surfaces: Roughen galvanized surfaces of slip critical bolted connections by hand wire brushing in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts as a Class C faying surface.

2.06 SOURCE QUALITY CONTROL

A. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test fabrication welds as specified in Section 05 05 23, Structural Welding.
2. Visually inspect fabrication welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. The Approved AISC Certified Fabricator will perform the inspection and testing of fabrication welds as specified in Section 05 05 23, Structural Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Structural Welding.

PART 3 EXECUTION

3.01 ERECTION

A. General:

1. Meet requirements of AISC 360 and AISC 303, with exceptions as specified.
2. Install Contractor-designed temporary construction bracing to provide necessary support until components are in place and construction is complete.
3. Provide additional field connection material as required by AISC 303.
4. Splice members only where indicated and accepted on Shop Drawings.

B. Field Assembly:

1. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly.
2. Set structural frames accurately to lines and elevations shown.
3. Align and adjust various members forming a part of a complete frame or structure before permanently fastening.

4. Level and plumb individual members of structure within tolerances shown in AISC 303.
5. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be completed and in service.
6. Perform necessary adjustments to compensate for minor discrepancies in elevations and alignment.

C. Setting Baseplates and Bearing Plates:

1. Clean concrete and masonry bearing surfaces of bond reducing materials and roughen to improve bond to surfaces.
2. Clean bottom surface of baseplates and bearing plates.
3. Set loose and attached baseplates and bearing plates for structural members on wedges, shims, leveling nuts, or other adjustable devices. Use leveling plates where indicated.
4. 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 placing grout. Weld plate washer to baseplate where indicated.
5. Grout Under Baseplate: As specified in Section 03 62 00, Grouting, prior to placing loads on structure.

D. Anchor Bolts:

1. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in-place work.
2. Provide templates and other devices for presetting bolts and other anchors to accurate locations.
3. Projection of anchor bolts beyond face of concrete and threaded length shall be adequate to allow for full engagement of threads of hold-down nuts, adjustment of leveling nuts, washer thicknesses, and construction tolerances, unless indicated otherwise.
4. Placement Tolerances:
    a. As required by AISC 303, unless indicated otherwise.
    b. Embedded anchor bolts shall not vary from dimensions shown on Drawings by more than the following:
        1) Center-to-Center of Any Two Bolts Within an Anchor Group: 1/8 inch.
        2) Center-to-Center of Adjacent Anchor Bolt Groups: 1/4 inch.
        3) Variation from Perpendicular to Theoretical Bearing Surface: 1:50.

E. Connections:

1. High-Strength Bolted:
   a. Tighten in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
   b. Pretension all bolts unless noted otherwise on Drawings.
   c. Hardened Washers:
      1) Provide at locations required by Washer Requirements section of RCSC Specification for Structural Joints Using High Strength Bolts, to include pretensioned and slip critical connections using slotted or oversized holes or ASTM A490 bolts.
      2) Use beveled style and extra thickness where required by RCSC Specification.
      3) Use square or rectangular beveled washers at inner flange surfaces of American Standard beams and channels.
      4) Do not substitute DTIs for hardened flat washers required at slotted and oversize holes.
   d. For snug-tightened connections (N, X), tighten to snug tight condition. Use hardened washer over slotted or oversize holes in outer plies.
2. Pretensioned Bolted:
   a. Use DTIs or twist-off-type tension-control (TC) bolts at slip critical (SC) and pretensioned bearing-type connections.
   b. DTIs:
      1) Position within bolted assembly in accordance with ASTM F959.
      2) Install bolts, with DTIs plus hardened washers as required, in holes of assembly and tighten until plies are in firm contact and fasteners are uniformly snug tight.
   c. Final tightening bolts begin at most rigid part of bolted connection and progress toward free edges until final twist-off-type tension-control (TC) bolts or until DTIs have been compressed to an average gap equal to or less than shown in ASTM F959, Table 2.
3. Welded:
   a. As specified in Section 05 05 23, Structural Welding.
   b. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

3.02 MISFITS

A. At Bolted Connections:

1. Immediately notify Engineer for approval of one of the following methods of correction:
   a. Ream holes that must be enlarged to admit bolts and use oversized bolts.
   b. Plug weld misaligned holes and redrill holes to admit standard size bolts.
   c. Drill additional holes in connection, conforming to AISC for bolt spacing and end and edge distances, and add additional bolts.
   d. Reject member containing misfit, incorrect sized, or misaligned holes and fabricate new member to ensure proper fit.
2. Do not enlarge incorrectly sized or misaligned holes in members by burning or by use of drift pins.

B. At Anchor Bolts:

1. Resolve misalignments between anchor bolts and bolt holes in steel members in accordance with approved Shop Drawing.
2. Do not flame cut to enlarge holes without prior approval of Engineer.

C. Gas Cutting:

1. Do not use gas cutting torches in field for correcting fabrication errors in structural framing.
2. Secondary members not under stress and concealed in finished structure may be corrected by gas cutting torches, if approved by Engineer.
3. Finish flame-cut sections equivalent to sheared and punched appearance.

3.03 REPAIR AND CLEANING

A. Clean shop primer from field welds, bolted connections, and abraded areas immediately after erection.

B. Remove and grind smooth tack welds, fit-up-lugs, and weld runoff tabs.

C. Remove weld back-up bars and grind smooth where indicated on Drawings.

D. Apply touchup paint primer by brush or spray of same thickness and material as that used in shop application and as specified in Section 09 90 00, Painting and Coating.

E. Hot-Dip Galvanized Coating Repair:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

3.04 FIELD FINISH

A. Field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on the Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspect and test as required in Section 01 45 16.13, Contractor Quality Control.

C. High-Strength Bolted Connections:

1. An independent testing agency will be retained by Owner to perform the following inspection and testing in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts:
   a. Marking identification and conformance to ASTM standards.
   b. Alignment of bolt holes.
   c. Placement, type, and thickness of hardened washers.
   d. Tightening of bolts.
2. Snug-Tightened Connections (N, X): Snug tight condition with plies of joint in firm contact.
3. Pretensioned Bearing and Slip Critical (SC) Connections:
   a. Conduct preinstallation test.
   b. Monitor installation and tightening of DTIs or TC bolts.
   c. Monitor condition of faying surfaces for slip critical connections.

4. Preinstallation Test:
   a. Conduct test in accordance with Specification for Structural Joints Using ASTM A325 or ASTM A490 bolts prior to using bolt tension measuring device.
   b. Select representative sample of not less than three bolts of each diameter, length, and grade.
   c. Include DTIs and flat hardened washers as required to match actual connection assembly.
5. Nondestructive Testing (NDT): Inspect bolted connections and perform corrections as required to meet code acceptance criteria per RCSC Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts.
6. Defective Connections: Correct and reinspect defective and improperly tightened high-strength bolted connections. Retest pretensioned bolts as necessary to demonstrate compliance of completed work.

D. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test field welds as specified in Section 05 05 23, Structural Welding.
2. Visually inspect field welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. An independent testing agency will be retained by Owner to perform inspection and testing of field welds as specified in Section 05 05 23, Structural Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Structural Welding.

E. Special inspection will be provided by Owner as indicated on Drawings.

END OF SECTION

SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
   a. Inspection of Hot-Dip Galvanized Steel Products.
   b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
7. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D1.2/D1.2M, Structural Welding Code - Aluminum.
   c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
8. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Specification for Gray Iron Castings.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
k. A276, Standard Specification for Stainless Steel Bars and Shapes.
l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
r. A489, Standard Specification for Carbon Steel Lifting Eyes.
s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
aa. A992/A992M, Standard Specification for Structural Steel Shapes.
bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.

ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
ii. F436, Standard Specification for Hardened Steel Washers.
jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ll. F594, Standard Specification for Stainless Steel Nuts.
mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

9. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
10. Occupational Safety and Health Administration (OSHA):
    a. 29 CFR 1910.27, Fixed Ladders.
    b. 29 CFR 1926.105, Safety Nets.
    c. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
11. Specialty Steel Industry of North America (SSINA):
    a. Specifications for Stainless Steel.
    b. Design Guidelines for the Selection and Use of Stainless Steel.
    c. Stainless Steel Fabrication.
    d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.

B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

C. Exterior Area: Location not protected from weather by building or other enclosed structure.

D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.
2. Samples: Color samples of abrasive stair nosings.

B. Informational Submittals:

1. Pre-engineered Ladders: Letter of certification that ladder meets OSHA 29 CFR 1910.27 requirements.
2. Passivation method for stainless steel members.
3. Galvanized coating applicator qualifications.
4. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

1.06 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of sidewalk doors and floor hatches found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

1.07 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following extra materials:

Item	Quantity
Neoprene Gasket	Two for each location requiring neoprene gaskets.
4 inches wide by 50 feet long Neoprene Gasket Material	One roll for each location requiring neoprene gaskets.
Neoprene Gasket Adhesive	One (manufacturer's recommended) for each location requiring neoprene gaskets.

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit the combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon (such as plates over 1.5 inches thick for ASTM A36/A36M steel), limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

B. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes

Item	ASTM Reference
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy 6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 304 (304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 55, with weldability supplement S1.
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D

Item	ASTM Reference
Welded Anchor Studs	A108, Grades C-1010 through C-1020
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

C. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

1. Plastic:
   a. Single unit construction with corrugated sleeve.
   b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
   c. Material: High-density polyethylene.
2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

A. See Section 05 05 19, Post-Installed Anchors.

2.04 STUD SHEAR CONNECTORS

A. Headed anchor studs (HAS), or threaded anchor studs (TAS),or stud shear connectors, as indicated on Drawings.

1. Carbon Steel: ASTM A108, Standard Quality Grades 1010 through 1020, inclusive either semikilled or killed aluminum or silicon dioxidation, unless indicated otherwise.
2. Stainless Steel: ASTM F593, AISI Type 316, Condition CW, where indicated.

B. Manufacturers:

1. Nelson Stud Welding, FabriSteel Co., Elyria, OH.
2. Stud Welding Associates, Inc., Elyria, OH.

2.05 PIPE SLEEVES

A. As specified in Section 33 05 01, Conveyance Piping—General.

2.06 EMBEDDED STEEL SUPPORT FRAMES FOR GRATING

A. Steel angle support frames to be embedded in concrete shall be stainless steel, ASTM A276, AISI Type 316, unless indicated otherwise.

B. Welded anchors for stainless steel support frames shall also be stainless steel.

2.07 ABRASIVE NOSING FOR STAIRS

A. Unless otherwise shown on Drawings, furnish flush type abrasive nosings on stairs.

B. Nosing Components:

1. Homogeneous epoxy abrasive, with minimum 50 percent aluminum oxide content, formed and cured upon an extruded aluminum base.
2. Epoxy abrasive shall extend over and form curved front edge of nosing.
3. Base of Nosing: Extruded aluminum alloy, 6063-T5, heat-treated.

C. Anchoring System: Double-set anchors consisting of two rows of integrally extruded anchors.

D. Size: 3 inches wide by 1/4 inch to 3/8 inch thick by length as shown.

E. Color: Selected by Engineer from manufacturer's standard color range.

F. Manufacturers and Products:

1. Wooster Products, Inc., Wooster, OH; Spectra Type WP3J for concrete filled steel pans and Spectra Type WP3C for cast-in-place concrete stairs.
2. American Safety Tread Co., Inc., Helena, AL; Type BF-311D for concrete filled steel pans and Type FA-311D for cast-in-place concrete stairs.

2.08 SIDEWALK DOORS

A. Load Capacity: 300 psf with maximum deflection of 1/150th of span. Provide H-20 wheel loading capacity where indicated on Drawings.

B. Component Fabrication:

1. Access Door Leaf(s): 1/4-inch aluminum diamond pattern plate. Provide stainless steel safety chain and attachments for end of double-leaf door assembly when open.
2. Channel Frame: 1/4-inch-thick extruded aluminum trough frame with continuous anchor flange around perimeter. Weld 1-1/2-inch diameter drain coupling, and drain pipe, to frame trough at front right corner, unless indicated otherwise on Drawings.

C. Door Hardware:

1. Hinges: Heavy-duty brass or stainless steel with stainless steel pins through-bolted to cover plate with tamper-proof stainless steel bolts flush with top of cover and to outside leg of channel frame with stainless steel bolts and locknuts.
2. Lifting Mechanism: Stainless steel compression lift springs enclosed in telescoping vertical housing or stainless steel torsion lift springs.
3. Hold-Open Arm:
   a. Locks automatically in open position.
   b. Disengages with slight pull on vinyl grip with one hand.
   c. Door can be easily closed with one hand by pulling forward and down on vinyl grip.
4. Snap Lock:
   a. Stainless steel snap lock mounted on bottom of door leaf with removable topside key wrench and inside fixed lever handle.
   b. Threaded plug for flush outside surface with key wrench removed.

D. Intrusion Detection: Provide built-in (by hatch manufacturer) intrusion detection switch for each hatch accessing vault with an RTU.

E. Aluminum: Mill finished with protective coating applied to surfaces to be in contact with concrete, as specified in Section 09 90 00, Painting and Coating.

F. Slip-resistant Surface:

1. For doors installed in pedestrian rights-of-way (such as, sidewalks), doors shall be provided with a textured surface meeting or exceeding OSHA and ADA recommended standards for walkways.

2. Manufacturer and Product:
   a. Syracuse Castings, Cicero, NY; SAFETY SURE GRIP.
   b. “Or-equal.”

G. Manufacturers and Products:

1. Cyracuse Castings, Cicero, NY; D Series.
2. Bilco Co., New Haven, CT; J Series.
3. Nystrom Products Co., Minneapolis, MN; FG Series.
4. U.S.F. Fabrication, Hialeah, FL; T Series.
5. ITT Flygt Corporation, Trumbull, CT; FDRN Series.
6. Thompson Fabricating Co., Birmingham, AL; TE Series.
7. Halliday Products, Orlando, FL; WS Series.

2.09 ROOF HATCHES

A. Load Capacity: 40 psf.

B. Material:

1. Cover and Frame:
   a. Aluminum: 11-gauge aluminum.
   b. Stainless Steel: Type 304 stainless steel.
2. Hardware: Type 316 stainless steel.

C. Cover: Brake formed, hollow-metal design with 1-inch concealed fiberglass insulation, 3-inch beaded, overlapping flange, fully welded at corners, and internally reinforced.

D. Curb: 12-inch in height with integral capflashing, 1-inch fiberboard insulation, fully welded at corners, and 3-1/2-inch mounting flange with 7/16-inch holes provided for securing frame to the roof deck.

E. Gasket: Extruded EPDM rubber gasket permanently adhered to cover.

F. Hinges: Heavy-duty pintle hinges with 3/8-inch Type 316 stainless steel hinge pins.

G. Latch: Slam latch with interior and exterior turn handles and padlock hasps.

H. Lift Assistance: Compression spring operators enclosed in telescopic tubes. Automatic hold-open arm with grip handle release.

I. Performance Ratings: Complies with UL 790 Class A (burning brand test).

J. Finish: Mill finish. Aluminum shall be mill finished with protective coating applied to surfaces to be in contact with concrete, as specified in Section 09 90 00, Painting and Coating.

K. Intrusion Detection: Provide built-in (by hatch manufacturer) intrusion detection switch for each hatch accessing vault with an RTU.

L. Manufacturer and Product:

1. Bilco Co., New Haven, CT; S or E Series.
2. “Or-equal.”

2.10 HATCH SAFETY NET

A. General:

1. Conforms to ASSE A10.11 and OSHA CFR Part 1926.105.
2. Size to fit hatch opening where indicated.

B. Components and Accessories:

1. Rails and Slide Rings: Aluminum 6061-T6 extruded rails and aluminum-alloy 713.0 slide rings.
2. Corner Hooks and Eyebolts: AISI Type 316 stainless steel.
3. Netting: Polyester, 5-inch by 5-inch net openings; 5,000 pounds minimum breaking strength.
4. Bolts, Nuts, and Concrete Anchors: AISI Type 316 stainless steel.

C. Manufacturer and Product: Safe Approach Inc., Auburn, ME; Hatch Net 121.

2.11 LADDERS

A. Fabricate ladders with rails, rungs, landings, and cages to meet applicable requirements of OSHA, CFR Part 1910.27, and ALI A14.3.

1. Design ladder for concentrated load of 250 pounds plus 30 percent impact on rungs imposed by user concentrated at points that will cause maximum stress in structural member being considered.
2. Maximum run deflection of L/360.
3. Design attachments for concentrated load of 250 pounds plus 30 percent impact between consecutive attachments.
4. Include weight of ladder and attached appurtenances together with live load in design of rails and fastenings.
5. Self-closing gates at landings.

B. Flat Bar Ladder:

1. Material as indicated on Drawings.
   a. Stainless Steel: ASTM A276, AISI Type 316.
   b. Galvanized Steel: Hot-dip galvanize steel after fabrication in accordance with ASTM A123/A123M and ASTM A385/A385M.
2. Punch rails, pass rungs through rails, and weld on outside.
3. Weld brackets to ladder for fastening ladder to wall.

C. Pipe Ladder:

1. Material: As indicated on Drawings.
   a. Stainless Steel: ASTM A276, AISI Type 316.
   b. Galvanized Steel: Hot-dip galvanize steel after fabrication in accordance with ASTM A123/A123M and ASTM A385/A385M.
   c. Rungs: Non-slip grip surface, 1-inch wide flat top, and semicircular bottom with mill finish.
   d. Side Rails: Schedule 40 pipe.
   e. Fasteners for Ladder Attachments: Stainless steel expansion anchors.
   f. Pop riveted or glued construction is not acceptable.
   g. Furnish support attachments to side rails at 6 feet maximum spacing.

D. Ladder Safety Post:

1. Telescoping tubular, spring balanced and automatically locking in raised position, with release lever for unlocking.
2. Post material to match ladder.
3. Post: Hot-dip galvanized steel in accordance with ASTM A123/A123M or stainless steel, AISI Type 304.
4. Hardware: Stainless steel, AISI Type 316.
5. Furnish dissimilar metal protective coatings at connections.
6. Manufacturer and Product: Bilco Co., New Haven, CT; “Ladder Up” to fit ladder rungs.

2.12 SAFETY CLIMB DEVICE

A. General:

1. Conforms to ALI A14.3 and OSHA CFR Part 1910.27.
2. Belt and harness shall withstand minimum drop test of 250 pounds in 6-foot free fall.
3. Fall Prevention System Material to match ladder: Hot-dip galvanized steel in accordance with ASTM A123/A123M or stainless steel, AISI Type 316.

B. Components and Accessories:

1. Main Components: Sleeve or trolley, safety harness, and carrier or climbing rail.
2. Ladder rung clamps with hot-dip galvanized steel or stainless steel, AISI Type 316 mounting brackets and hardware to match ladder.
3. Removable extension kit with tiedown rod or trolley gate, mandrel, and carrier rail for ladders under manholes and hatches.

C. Manufacturers and Products:

1. Miller by Honeywell, Franklin, PA; Miller Saf-T-Climb.
2. TS Products, Cambridge, Ontario, Canada; TS Safety Rail System.

2.13 FALL ARREST ANCHORS

A. General:

1. Conforms to OSHA CFR Part 1926.502.
2. Minimum Breaking Strength: 5,000 pounds.
3. Material: Stainless steel, AISI Type 304.

B. Components and Accessories:

1. Forged combination eye and base assembly with headed anchor bolt, backer plate, lock washer, and nut.
2. Suitable for embedment in concrete wall or slab.

C. Manufacturers and Products:

1. Thaler Metal Industries, Buffalo, NY; FARA Wall Anchor.
2. Rose Manufacturing Company, Pittsburgh, PA; Anchorage Connector.

2.14 THREADED INSERTS

A. Unless indicated otherwise, threaded inserts shall satisfy the following requirements:

1. Ductile iron construction with standard N.C. threads.
2. Cast-in-place at locations shown on the Drawings.
3. Manufacturer: Meadow Burke “Or-equal.”

2.15 FABRICATED UNITS

A. Weir or Staff Gauge: Porcelain enameled, length as indicated on Drawings, featuring graduation marks every 1/100th foot and marked

numerically at every foot and every tenth foot as manufactured by Stevens Water Monitoring Equipment, Beaverton, OR; Style C.

B. Weir and Baffle Plates: Fabricate plates and associated framing of stainless steel, AISI Type 316 or aluminum alloy 6061-T6 using welding filler wire as manufactured by Alcoa, No. 4043, with material as indicated on Drawings.

2.16 CASTINGS

A. Manhole Covers and Frames:

1. Cast iron and designed for AASHTO HS-20 loading.
2. Castings shall be smooth, clean and free from blisters, blowholes, and shrinkage.
3. Covers shall seat firmly into frames without rocking.
4. Covers and frames shall fit together evenly such that the cover fits flush with the surrounding finished surface.
5. See Drawings for additional information.

2.17 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

B. Neoprene Gasket:

1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on Drawings.
2. Thickness: Minimum 1/4 inch.
3. Furnish without skin coat.
4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

C. Ultra-High Molecular Weight Polyethylene (UHMW):

1. Satisfy requirements of ASTM D4020.
2. Minimum Density: 55 pcf in accordance with ASTM D792.
3. Minimum Yield Strength: 3 ksi in accordance with ASTM D638.
4. Minimum Elongation at Yield: 15 percent in accordance with ASTM D638.
5. Sand Wheel Wear: 90 (AR-01) in accordance with ASTM G65.

6. Minimum Shore Hardness: 90.
7. Maximum Static Friction: 0.15 in accordance with ASTM D1894.

2.18 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer's instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar

metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

G. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for project conditions. Cover full bearing surfaces.

H. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

I. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.19 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.

2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

B. Hot-Dip Galvanizing:

1. An independent testing agency shall be retained by Contractor and approved by Engineer to inspect and test hot-dip galvanized fabricated items, except in accordance with ASTM A123/A123M and ASTM A153/A153M.
2. Visually inspect and test for thickness and adhesion of zinc coating for minimum of three test samples from each lot in accordance with ASTM A123/A123M and ASTM A153/A153M.
3. Reject and retest nonconforming articles in accordance with ASTM A123/A123M and ASTM A153/A153M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer's recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.
3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at time concrete is placed.

B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.

C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 ABRASIVE NOSINGS

A. Provide abrasive nosings on concrete steps not being supplied or coated with another type of nosing or nonskid material.

3.04 ACCESS COVERS

A. Install access covers, including sidewalk doors in accordance with manufacturer's instructions.

B. Accurately position prior to placing concrete, such that covers are flush with floor surface.

C. Protect from damage resulting from concrete placement. Thoroughly clean exposed surfaces of concrete spillage to obtain a clean, uniform appearance.

D. Route drain pipe to exterior face of concrete or as shown on Drawings.

E. Position cover so that hinge is on side opposite ladder.

3.05 SAFETY CLIMB DEVICE SYSTEM

A. Provide for each ladder where unbroken height between levels exceeds 20 feet, or at lesser height where indicated on Drawings.

B. Install in accordance with manufacturer's instructions.

C. Furnish additional accessories required to complete system for each ladder.

D. Furnish one harness for each ladder equipped with safety climb device.

E. Furnish pivot section at platforms, landings, and roofs.

F. When installed to required height, fall prevention system shall be rigid and an integral part of the structure.

3.06 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

C. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

3.07 PAINTING AND REPAIR OF GALVANIZED STEEL

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.08 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

B. Quality Control:

1. Inspection and testing required in Section 01 45 16.13, Contractor Quality Control.
2. Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements and Section 01 88 15, Anchorage and Bracing.

C. Stud Shear Connectors:

1. At start of each production period, conduct the following test to determine proper generator, control unit, and stud welding gun settings, in accordance with AWS D1.1/D1.1M, Chapter 7:
   a. Weld two test studs and visually inspect for full 360-degree flash.
   b. Bend test studs 30 degrees from vertical for headed anchor studs (HAS). Torque test threaded anchor studs (TAS) studs per AWS D1.1/D1.1M, Section 7.6.6.2.
   c. Test studs will be acceptable if there is no failure of welds.
   d. If weld fails, repeat test until two consecutive test studs test to be satisfactory.
2. During production, if visual inspection reveals weld does not exhibit full 360-degree flash or that stud has been repaired by welding, conduct the following test in accordance with AWS D1.1/D1.1M, Chapter 7:
   a. Bend HAS studs or stud shear connectors approximately 15 degrees from vertical, away from missing portion of flash. For TAS studs, torque test per AWS D1.1/D1.1M, Section 7.6.6.2.
   b. Studs meeting this test without exhibiting cracks in weld will be considered acceptable and left in bent position.
   c. Replace studs failing test.

3.09 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09 90 00, Painting and Coating
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09 90 00, Painting and Coating
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		
4. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
5. Connections for Steel Fabrications		
Exterior and Interior Wet and Dry Areas	Hot-dip galvanized carbon steel bolted connections	

Service Use and Location	Product	Remarks
6. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
7. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 05 52 19
STEEL RAILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Iron and Steel Institute (AISI): As applicable.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   e. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   f. E894, Standard Test method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
   g. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
   h. F1554, Standard Specification for Anchor Bolts, Steel, 36-, 55-, and 105-ksi Yield Strength.
3. International Code Council (ICC):
   a. 2018 International Building Code (IBC).
   b. Evaluation Services Reports, as applicable.
4. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term shall include guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

C. Special Inspection: As defined by the ICC IBC.

D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Submit proposed details for gate latch and stop for approval.
2. Design Data: Where proposed design differs from the details shown on Drawings, submit calculations or test data for alternate system using ICC IBC design loads and requirements.

1.04 QUALITY ASSURANCE

A. Qualifications: Calculations required for alternate designs (if proposed) shall be stamped by a registered civil or structural engineer licensed in the state of Utah.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Railings adequately packaged and wrapped to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to the extent possible until railing is completely installed.

PART 2 PRODUCTS

2.01 GALVANIZED STEEL RAILINGS

A. General: Hot-dip galvanize unless indicated otherwise.

B. Pipe Railings/Round HSS:

1. ASTM A500/A500M Grade B.
2. Outside Diameter: 1.900-inch.
3. Wall Thickness:
   a. Rail: 0.145-inch, minimum.
   b. Post: 0.200-inch, minimum.

C. Accessories, including railing components, flanges, wall brackets, anchor plates, shall conform to the following:

1. Post Bolted Baseplate: ASTM A36/A36M.
2. Wall Brackets:
   a. Malleable iron, round top, and galvanized.
   b. Manufacturers and Products:
      1) The Wagner Companies; No. 1765.
      2) Julius Blum & Co., Inc.; No. 1382.
3. Rail Terminals (including Wall Returns):
   a. Round, galvanized steel, welded to rail, with two 5/16-inch holes for 1/4-inch fasteners.
   b. Manufacturer: The Wagner Companies.
4. Railing System Gate:
   a. As specified herein for galvanized steel pipe.
   b. Gate Hardware: AISI Type 304 or Type 316 stainless steel.
5. Railing Picket Panels and Clamps:
   a. Galvanized steel, solid bar or pipe meeting minimum requirements specified for pipe rails.
   b. Fasteners: Galvanized steel or stainless steel.
6. Toeboards and Accessories:
   a. ASTM A36/A36M steel hot-dip galvanized.
   b. Toeboards: Provide slotted holes for expansion and contraction where required.
   c. Fasteners: Galvanized steel or stainless steel.

D. Metal supports embedded in concrete: In accordance with Section 05 05 19, Post-Installed Anchors.

E. Miscellaneous Fasteners: Galvanized steel or stainless steel.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): Galvanized steel or stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: Hot-dipped galvanized ASTM A325 bolts.

C. Concrete Anchors:

1. Galvanized steel anchor rods conforming to ASTM F1554, Grade 36 except at stainless steel railing anchors shall be AISI Type 316 stainless steel.

2. Post-installed anchors shall be in accordance with Section 05 05 19, Post-Installed Anchors, unless otherwise specified herein.
3. Bolt Diameter: 1/2 inch minimum.

2.03 FABRICATION OF WELDED STEEL RAILINGS

A. Shop Assembly:

1. Post spacing and railing details shall be as shown on Drawings.
2. Post to Baseplate Connection: Field fit-up is required as shown on Drawings.
3. Alternate Post to Baseplate Connection:
   a. Field measure elevation of concrete at each post location and determine exact post length so baseplate is on concrete surface.
   b. Rails shall be in straight alignment when rails to posts and posts to baseplates are welded.
   c. Field weld posts to baseplates.
4. Remove burrs from cut edges.
5. Form elbow bends and wall returns to uniform radius, free from buckles and twists, with finished surfaces smooth.
6. Cover exposed ends of steel pipe by welding 1/8-inch minimum thickness steel plate in place or use prefabricated fittings.
7. Welding:
   a. In accordance with Section 05 05 23, Structural Welding.
   b. Thoroughly fuse without undercutting or overlap.
   c. Remove splatter, grind exposed welds to blend, and contour surfaces to match those adjacent.
   d. Grind welds prior to hot-dip galvanizing of railing sections.
8. Furnish explosion prevention holes at closed ends of pipes.
9. Form and assemble joints exposed to weather to prevent water and moisture from penetrating.

B. Shop/Factory Finishing: After fabrication hot-dip galvanize steel components, other than stainless steel components, in accordance with ASTM A123/A123M.

C. Tolerances:

1. Cut pipe square within 2 degrees and lengths within 1/8 inch.
2. Welding: Miter and cope intersections of posts and rails within 2 degrees, fit to within 0.020 inch, and perform continuous welds around joints.

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

B. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

C. Modification to supporting structure is not permitted where railing is to be attached.

D. Mount railings only on completed walls. Do not support railings temporarily by means not satisfying structural performance requirements.

E. Protection from Entrapped Water:

1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.
2. For posts mounted in concrete, bends, and elbows occurring at low points drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

A. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural movement joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span movement joints in structural walls and floors supporting the posts.

B. Posts and Rails:

1. Surface Mounted and Side Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Install to account for small variation in leveling grouts and shims between adjacent posts.

2. Grouted Posts:
   a. Clean dust and foreign matter from sleeves or blockouts.
   b. Moisten interior of hole and surrounding surface with clean water. Fill hole with nonshrink grout or epoxy grout prior to installing post.
   c. Brace railing until grout sets.
   d. Posts installed outside and exposed to freezing temperatures: drill weep hole through post approximately 1/2 inch above level of grout inside post and in plane of rail to prevent entrapment and freezing of water inside post.
3. Set posts plumb and aligned to within 1/8 inch in 12 feet.
4. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
5. Install posts and rails in same plane.
6. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
7. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
8. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

C. Wall Brackets:

1. Support wall rails on brackets as shown on Drawings.
2. Install wall anchor backplates on solid blocking in stud walls.

D. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or on stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation, cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

B. Treatment of Field Welds for Galvanized Steel Railings: Touch up welds by application of two coats high-zinc dust content paint to dry film thickness of 2 mils.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on the Drawings.

C. Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

END OF SECTION

SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   d. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
3. National Association of Architectural Metal Manufacturers (NAAMM):
   a. MBG 531, Metal Bar Grating Manual.
   b. MBG 532, Heavy-Duty Metal Bar Grating Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
   c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
   d. Manufacturer's specifications, including coatings, surface treatment, and finishes.

B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Factory assemble items insofar as practical.

B. Package and clearly tag parts and assemblies that are, because of necessity, shipped unassembled and protect the materials from damage, and facilitate identification and final assembly in the field.

PART 2 PRODUCTS

2.01 GRATING MATERIALS

A. General: Grating material shall be galvanized carbon steel unless indicated otherwise.

B. Galvanized Carbon Steel:

1. Bearing Bars, Banding, and Rectangular Cross Bars: ASTM A1011/A1011M commercial steel Type II for hot rolled carbon steel sheet and strip, or ASTM A36/A36M.
2. Finish: Galvanized after fabrication.

C. Stainless Steel:

1. Bearing Bars, Banding, and Cross Bars: ASTM A555, Type 304L.
2. Finish: Mill.

D. Aluminum:

1. Provide alloy and temper as designated below:
   a. Bearing Bars and Banding: ASTM B221 alloy 6061-T6 or 6063-T6.
   b. Swaged Crossbar Rods: ASTM B221 alloy 6061 or 6063, or ASTM B210 alloy 3003.
   c. Finish: Mill.

2.02 LIGHT DUTY GRATING (TYPE A OR FOOT TRAFFIC)

A. General Requirements:

1. Material:
   a. As indicated on Drawings.
   b. Galvanized steel unless indicated otherwise.
2. Uniform Service Load: 100 psf.
3. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
4. Bearing Bar Spacing: 1-3/16-inch maximum, center-to-center.

5. Cross Bar Spacing:
   a. Typical: 4-inch maximum center to center.
   b. For aluminum I-bar grating with depths greater than 2 inches, provide cross bars at 2 inches maximum, center to center.
6. Banding: 3/16-inch minimum width.
7. Bearing Bars and Cross Bars: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Fabrication:

1. Galvanized or stainless steel acceptable fabrication types:
   a. Welded, rectangular bar grating fabricated by electro-forging or welding cross bars to bearing bars.
   b. Pressure-locked rectangular bar grating fabricated by pressing rectangular crossbars into slots in rectangular bearing bars.
   c. Pressure-locked rectangular bar grating fabricated by swaging crossbars into slots in rectangular bearing bars.
2. Aluminum, pressure-locked rectangular bar grating fabricated by pressing crossbars between rectangular bearing bars.

C. Surface:

1. Provide surface as shown on Drawings.
   a. Plain unless otherwise noted.
   b. Serrated.
   c. Slip-resistant, consisting of applied abrasive finish of aluminum-oxide aggregate.
2. When surface of bars is serrated provide 1/4-inch deeper bearing bars than shown on Drawings to maintain specified load carrying capacity of grating.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.03 MEDIUM DUTY GRATING (TYPE B)

A. General Requirements:

1. Material:
   a. As indicated on Drawings.
   b. Galvanized steel, unless indicated otherwise.
2. Uniform Service Load: 300 psf.

3. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
4. Bearing Bar Spacing: 15/16-inch maximum, center-to-center.
5. Cross Bar Spacing:
   a. Typical: 4-inch maximum center to center.
   b. For aluminum I-bar grating with depths greater than 2 inches, provide cross bars at 2 inches maximum, center to center.
6. Banding: 3/16-inch minimum width.
7. Bearing Bars and Cross Bars: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Fabrication:

1. Galvanized or stainless steel acceptable fabrication types:
   a. Welded, rectangular bar grating fabricated by electro-forging or welding cross bars to bearing bars.
   b. Pressure-locked rectangular bar grating fabricated by pressing rectangular crossbars into slots in rectangular bearing bars.
   c. Pressure-locked rectangular bar grating fabricated by swaging crossbars into slots in rectangular bearing bars.
2. Aluminum, pressure-locked rectangular bar grating fabricated by pressing crossbars between rectangular bearing bars.

C. Surface:

1. Provide surface as shown on Drawings.
   a. Plain unless otherwise noted.
   b. Serrated.
   c. Slip-resistant, consisting of applied abrasive finish of aluminum-oxide aggregate.
2. When surface of bars is serrated provide 1/4-inch deeper bearing bars than shown on Drawings to maintain specified load carrying capacity of grating.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 HEAVY DUTY GRATING (TYPE C OR VEHICULAR)

A. General Requirements:

1. Material:
   a. As indicated on Drawings.
   b. Galvanized steel unless indicated otherwise.
2. Service Load: AASHTO H-20.
3. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
4. Bearing Bar Spacing: 1-7/8-inch maximum, center-to-center.
5. Cross Bar Spacing: 4-inch maximum center to center.
6. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 532 or as shown on Drawings.

B. Fabrication:

1. Galvanized or stainless steel acceptable fabrication types:
   a. Weld cross bars between rectangular bearing bars.
   b. Press deep rectangular crossbars into slots in rectangular bearing bars.

C. Surface: Plain, unless indicated otherwise.

2.05 ACCESSORIES

A. Embedded Frames: As indicated on Drawings and as specified in Section 05 50 00, Metal Fabrications.

B. Grating Clamps:

1. Use at flanged beam and bolted angle frame supports.
2. Removable from above grating walkway surface.
3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
4. Manufacturers and Products:
   a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
   b. Grating Fasteners, Inc., Harvey, LA; G-Clip.

C. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.

4. Manufacturers and Products:
   a. Welded Stud Anchor:
      1) Nelson Stud Welding, Inc., Elyria, OH.
      2) Stud Welding Associates, Inc. Elyria, OH.
   b. Saddle Clip:
      1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
      2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
      3) Struct-Fast, Inc., Baltimore, MD; Gratefast.

2.06 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Cutouts:
   a. Fabricate in grating sections for penetrations indicated.
   b. Arrange to permit grating removal without disturbing items penetrating grating.
   c. Edge band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
6. Do not notch bearing bars at supports to maintain elevation.
7. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
8. Section Length: Sufficient to prevent section from falling through clear opening when oriented in the span direction and one end is touching either the concrete or the vertical leg of grating support.
9. Minimum Bearing: 1 inch for grating depth up to 2-1/4 inches and 2 inches for grating depth greater than 2-1/4 inches.
10. Banding and Toe Plates: Same material as grating and welded to bearing bars in accordance with requirements of NAAMM MBG 531 and NAAMM MBG 532.

B. Foot Traffic Rated Metal Bar Grating: A single grating section shall be not less than 1.5 feet or greater than 3 feet in width, or weigh more than 150 pounds.

C. Vehicle Traffic Rated Metal Bar Grating: Minimum width of grating sections shall be 2 feet regardless of length and weight.

D. Supports:

1. Same material as grating, except supports which are to be embedded in concrete shall be Type 316 stainless steel.
2. Coordinate dimensions and fabrication with grating to be supported.
3. Coordinate dimensions with increased depth because of serrations.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09 90 00, Painting and Coating.
2. Allow paint to dry before installation of material.

3.02 INSTALLATION

A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in the area of potential fall hazard.

B. Install manufactured products in accordance with manufacturer's recommendations.

C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.

D. Install grating supports plumb and level as applicable.

E. Install sections of welded frames with anchors to straight plane without offsets.

F. Field locate and install fasteners to fit grating layout.

G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.

H. Each grating or plank section shall be easily removable and replaceable.

I. Completed installation shall be rigid and neat in appearance.

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

SECTION 06 10 00
ROUGH CARPENTRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Wood Council (AWC): 2, National Design Specification for Wood Construction.
2. American Lumber Standards Committee's Board of Review (ALSC).
3. American Wood Preservers' Association (AWPA):
   a. U1, User Specification for Treated Wood.
   b. M4, Standard for the Care of Preservative-Treated Wood Products.
4. APA - The Engineered Wood Association (APA):
   a. PRP-108, Performance Standards and Qualification Policy for Structural-Use Panels (Form E445).
   b. Form B445, APA Quality Assurance Policies for Structural-Use Panels Qualified to PRP-108.
5. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   c. C1177/C1177M, Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing.
   d. D412, Standard Test Methods For Vulcanized Rubber And Thermoplastic Elastomers – Tension.
   e. D4541, Standard Test Method For Pull-Off Strength Of Coatings Using Portable Adhesion Testers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   g. E96, Standard Test Methods For Water Vapor Transmission Of Materials.
   h. E331, Standard Test Method For Water Penetration Of Exterior Windows, Skylights, Doors, And Curtain Walls By Uniform Static Air Pressure Difference.
   i. E2178, Standard Test Method for Air Permeance of Building Materials.
   j. F1667, Standard Specification for Driven Fasteners: Nails, Spikes, and Staples.

6. International Code Council (ICC):
   a. ESR-1539, Power-Driven Staples and Nails.
   b. International Building Code (IBC).
7. National Fire Protection Association (NFPA):
   a. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   b. 285, Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components.
8. UL: 723, Standard for Test for Surface Burning Characteristics of Building Materials.
9. U.S. Department of Commerce—Voluntary Product Standard (DOC):
   a. PS 1, Structural Plywood.
   b. PS 20, American Softwood Lumber Standard.
10. Western Wood Products Association (WWPA): G5, Western Lumber Grading Rules.

1.02 DEFINITIONS

A. ALSC: American Lumber Standards Committee's Board of Review.

B. AWC: American Wood Council.

C. DOC: Department of Commerce.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Indicate component materials and dimensions, and include construction and application details for the following:
      1) Sheathing.
      2) Metal framing anchors.
      3) Construction panel thickness where not shown.
      4) APA product reports in accordance with Building Code indicated on Structural General Notes on Drawings for structural composite lumber.

B. Informational Submittals:

1. ICC Evaluation Service Reports, including the following as a minimum:
   a. Connections and Fasteners.
   b. Wood Treatment.
   c. Nails.

2. Wood treatment manufacturer's instructions for handling, storing, installation, and finishing of treated material.
3. Material Certificates: Showing species and grade selected for dimensional lumber for each use.
    a. Material certificates for dimensional lumber in compliance with allowable unit stresses. Show species and grade selected for each use as well as design values approved by the ALSC's Board of Review.
    b. For each type of preservative-treated wood product, include certification by treatment plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
    c. For waterborne-treated products include statement that moisture content of treated materials was reduced to levels indicated prior to shipment to Site.
4. Material test reports from testing laboratory showing and interpreting test results in accordance with test methods UL 723, NFPA 255, and ASTM E84, relative to fire-retardant treated wood products.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Upon delivery to Site, immediately place materials in area protected from weather. Do not store seasoned materials in wet or damp areas.

B. Protect sheet materials from breaking corners and damaging surfaces while unloading.

C. Store materials a minimum of 6 inches above ground on framework or blocking and cover with waterproof covering, providing for adequate air circulation and ventilation. Store sheet materials flat, not on edge.

D. Protect fire-retardant materials against high humidity and moisture during storage and erection.

E. For lumber and plywood pressure treated with waterborne chemicals, place spacers between each bundle to provide air circulation.

F. Store materials for which maximum moisture content is specified in areas where humidity can be controlled.

PART 2 PRODUCTS

2.01 GENERAL

A. Lumber Standards:

1. In accordance with DOC PS 20 and applicable grading rules and wood species certified by ALSC.
2. Design values for wood members equal to those published in supplement to AWC 2.
3. Stamp or brand each unexposed piece of lumber with grade, species, and moisture content at time of mill surfacing.
4. Furnish exposed lumber pieces with grade stamps applied to ends or back of each piece. If completely exposed, and permitted by local building jurisdiction, omit grade stamps entirely.

B. Lumber sizes shown on Drawings are nominal, unless shown otherwise. Provide actual sizes as required by DOC PS 20 for use.

C. Dressed lumber S4S, unless shown otherwise on Drawings.

D. Moisture content of lumber not to exceed 19 percent, unless otherwise specified and marked “DRY”.

E. Each plywood panel identified with designated grade trademark of APA.

F. Lumber: FSC certified where indicated on Drawings.

2.02 LUMBER

A. Framing Lumber: Douglas Fir-Larch, No. 1 or better unless indicated otherwise below:

Usage	Minimum Grade
Blocking, furring, and nailers	Douglas Fir-Larch No. 2, Hemlock, nondense

2.03 CONSTRUCTION PANELS

A. Plywood:

1. General:
   a. Where construction panels are shown on Drawings for the following concealed types of applications, provide APA Performance-Rated Panels complying with requirements designated under each application for grade designation, span

rating, exposure durability classification, edge detail, and thickness.

b. Construction Panel Standards: Comply with DOC PS 1 for plywood construction panels and for products not manufactured under DOC PS 1 provisions, in accordance with APA PRP-108.

c. Trademark: Each construction panel factory-marked with APA trademark evidencing compliance with grade requirements.

2. Roof Sheathing: APA rated Plywood or Structural I sheathing.

a. Exposure Durability Classification: EXTERIOR.

b. Fire treated.

c. Thickness: Not less than 15/32 inch.

B. Plywood Backing Panel: Mounting electrical, telephone, and like equipment; provide fire-retardant treated plywood panel with grade designation, APA C-D Plugged Exposure 1, in thickness shown on Drawings, or, if not shown on Drawings, not less than 15/32 inch.

C. Gypsum Sheathing Board:

1. Glass-Mat Gypsum Sheathing Board:

a. In accordance with ASTM C1177/C1177M; Type X.

b. Thickness: 5/8-inch.

c. Manufacturer and Product (Basis of Design): G-P Gypsum Corp.; DensGlass Sheathing.

2.04 PRESERVATIVE WOOD TREATMENT BY PRESSURE PROCESS

A. Where lumber or plywood is indicated as preservative-treated wood, in accordance with AWPA U1 and AWPA M4, mark and grade each treated item in accordance with WWPA G5.

1. Kiln-dry after treatment to maximum moisture content of 19 percent.
2. Treat wood in contact with roofing or flashing.
3. Treat wood in contact with masonry or concrete.
4. Treat wood less than 18 inches above grade.

B. Aboveground Materials:

1. Pressure treat items with waterborne preservatives to a minimum retention of 0.25 per cubic foot.
2. Interior Use: After treatment, kiln-dry lumber and plywood to maximum moisture content of 19 percent and 15 percent respectively.

3. Treat the following items:
   a. Wood nailers, blocking, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
   b. Wood blocking, and similar concealed members in contact with masonry or concrete.

C. Complete fabrication of treated items prior to treatment, where possible. If cut after treatment, coat cut surfaces to comply with AWPA M4. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

2.05 FIRE-RETARDANT TREATED WOOD

A. Pressure treat lumber and plywood with fire-retardant chemicals in accordance with applicable AWPA U1 and AWPA M4 standard for species, product, preservative and end use to ensure flame-spread rating not higher than 25 with no evidence of significant progressive combustion when tested for 30 minutes duration under UL 723 and ASTM E84.

B. Treated lumber and plywood labeled and tested by UL shall show performance rating.

2.06 HARDWARE

A. Fasteners and connectors in contact with preservative-treated or fire-retardant-treated wood shall be hot-dipped zinc-coated galvanized steel or stainless steel in accordance with ASTM A153/A153M.

B. Conform to ASTM F1667.

C. Nails:

1. Conform to ASTM F1667.
2. Steel common nails.
3. Use hot-dipped zinc-coated nails wherever exposed.

D. Staples: Conform to ASTM F1667, galvanized where exposed.

E. Power Driven Fasteners: Conform to ICC ESR-1539.

F. Bolts and Screws: Conform to ASTM A307, galvanized where exposed.

G. Fasteners for Gypsum Sheathing Board:

1. Galvanized roofing nails 3/8-inch head to 7/16-inch head, 1-3/4 inches long.
2. Type S or W No. 6, 1-1/4 inches long drywall screws; meeting the requirements of ASTM C1002.

2.07 ACCESSORIES

A. Fluid-Applied Air and Water Barrier:

1. Fluid applied, single component, vapor permeable acrylic membrane; 59 percent solids content.
   a. Thickness: 44 mils wet film and 25 mils dry film.
2. Performance Requirements:
   a. Water Resistance of In-place Membrane: ASTM E331, pass.
   b. Pull Adhesion: ASTM D4541, greater than 30 psi (gypsum board).
   c. Tensile Strength: ASTM D412 – Die C, 110 psi.
   d. Enlongation: ASTM D412 – Die C, 250 percent.
   e. Surface Burning Characteristics: ASTM E84, Flame Spread Index, Class A and Smoke Developed Index, Class A.
   f. Wall Assembly Fire Test: NFPA 285, pass as part of various wall assemblies with foam plastic insulation.
   g. Water Vapor Transmission (Permeance): ASTM E96, 13.9 perms, maximum.
   h. Air Permeance of In-place Membrane: ASTM E2178, 0.0001 cfm/ft^2.
3. Use detailing components as recommended by membrane manufacturer.
4. Manufacturer and Product:
   a. GCP Applied Technologies; Perm-A-Barrier VPL.
   b. “Or-equal.”

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify surfaces to receive rough carpentry materials are prepared to exact grades and dimensions.

3.02 GENERAL

A. Lay out, cut, fit, and install rough carpentry items. Anchor sufficiently to ensure rigidity and permanence.

B. Install items accurate to dimension, true to line, level, and square unless shown otherwise on Drawings. Provide for installation and support of other Work.

C. Discard units of material with defects that impair quality of rough carpentry construction and that are too small to use in fabricating rough carpentry with minimum joints or optimum joint arrangement.

D. Countersink nailheads on exposed carpentry work and fill holes.

E. Make provisions for temporary construction loads, and provide temporary bracing sufficient to maintain structure in true alignment and safe condition until completion of erection and installation of permanent bracing.

F. Field treat field cuts and holes in pressure-treated lumber and timber with preservative in accordance with AWPA M4.

G. Holes: 1/16 inch larger than nominal bolt diameter, except provide holes for cast-in-place anchor bolts 3/16 inch larger than nominal bolt diameter.

1. Enlarge tight holes requiring forcible driving of bolts by reaming.

H. Provide washers under bolt heads and nuts bearing on wood.

3.03 INSTALLATION

A. Miscellaneous Framing:

1. Framing for Miscellaneous Items: Provide blocking and nailers as required for support of items shown on Drawings.

B. Roof Sheathing:

1. Install plywood panels over steel deck as indicated on Drawings.
2. Allow minimum space of 1/16 inch between end joints and 1/8 inch at edge joints for expansion and contraction of panels.
3. See rough carpentry section of General Structural Notes found on Drawings for fastener and spacing requirements.

C. Gypsum Sheathing Board:

1. Apply sheathing with long dimension horizontal.
2. Abut ends of sheathing at center of supports. Stagger end joints.
3. Attach sheathing using screws at 8-1/2 inches on center on galvanized hat channel supports.

D. Air and Water Barrier:

1. Install over sheathing. Where required by manufacturer, prime surface of sheathing in accordance with manufacturer's instructions.
2. Seal sheathing per manufacturer's recommendations.
3. Ship lap over adjacent pieces 6 inches minimum.
4. Lap over flashings 6 inches minimum.

3.04 PRESERVATIVE-TREATED WOOD PRODUCTS

A. Provide preservative-treated wood for framing, blocking, nailing strips built into exterior masonry walls, wood in contact with concrete or masonry and in conjunction with roofing.

B. Apply two brush coats of same preservative used in original treatment to sawed or cut surfaces of treated lumber.

3.05 FIRE-RETARDANT TREATED WOOD

A. Provide fire-retardant treated plywood for sheathing where indicated on Drawings.

B. Use FR-S rated wood on interior only.

C. Use exterior rated wood outside and where relative humidity is above 80 percent.

3.06 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Quality Assurance: In accordance with IBC Chapter 17 requirements and as indicated on the General Structural Notes on Drawings.

B. Quality Control: Inspect and test as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 07 14 00
FLUID-APPLIED WATERPROOFING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C836, Standard Specification for or High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course.
   b. C1330, Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   c. D412, Tensile Strength Test on Elastomers
   d. D624, Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer
   e. E96, Water Vapor Permeability.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Copies of manufacturer's literature for products proposed.
2. Samples: Cured membrane system applied to 6-inch square by 1/4-inch-thick plywood or similar rigid base.

B. Informational Submittals:

1. Certification from fluid applied waterproofing manufacturer: Compliance with product requirements specified.
2. Sample copy of guarantee to be provided. Upon completion and acceptance of the Work required by this section, submit an executed copy of guarantee.
3. Applicator approval letter from fluid applied waterproofing manufacturer.

1.03 QUALITY ASSURANCE

A. Applicator: Approved and licensed by fluid applied waterproofing manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project Site in sealed, undamaged containers. Identify each container with material name, date of manufacture, and lot number.

B. Store material in dry area out of direct sunlight. Storage area temperature shall not exceed 90 degrees F.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Perform Work only when existing and forecasted weather conditions are within limits established by manufacturer of materials and products used.

B. Proceed with installation only when substrate construction and preparation work is complete and in condition to receive waterproofing.

1.06 SPECIAL GUARANTEE

A. Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction or, at the option of Owner, removal and replacement of Work specified in this Specification section found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

PART 2 PRODUCTS

2.01 MEMBRANE

A. Single component, polyurethane elastomer-based fluid-applied waterproofing membrane for below grade walls; ASTM C836.

1. C836, Hardness: Shore A 50 – 85.
2. D412, Tensile Strength: 250 pounds per square inch, elongation minimum 300 percent.
3. D624, Tear Strength Minimum: 30 pounds per inch.
4. E96, Water Vapor Permeability Maximum: 0.1 perm.
5. Membrane Thickness: 60 -120 mils.

B. Manufacturers and Product:

1. The Neogard Corp., Dallas, TX; Perma-Gard III.
2. Carlisle Coatings and Waterproofing, Sapulpa, OK; MiraSEAL.

3. Sonneborn a Division of BASF, Shakopee, MN; MasterSeal HLM 5000.
4. GCP Applied Technologies, Inc., Cambridge, MA; Procor Below-Grade.

2.02 RELATED MATERIALS

A. As follows, compatible with components produced by membrane manufacturer:

1. Primers: As recommended by membrane manufacturer for type of substrate involved.
2. Sealants: Low modulus, unmodified polyurethane or as recommended by membrane manufacturer.
3. Backer Rod:
   a. Expanded closed-cell polyethylene foam rod.
   b. ASTM C1330.
   c. Compatible with waterproofing.
4. Flashing Reinforcement: Woven, uncoated fiberglass mesh on 0.050-inch thick precured neoprene.
5. Protection Board: As approved by membrane manufacturer.
6. Drainage Board: Provide as required by membrane manufacturer for Project conditions.

PART 3 EXECUTION

3.01 CONDITIONS OF SURFACES

A. Verify curing methods used for concrete are compatible with membrane system.

3.02 PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to receive membrane following membrane manufacturer's recommendations.
2. Treat as necessary to remove laitance, loose material on surface, grease, oil, and other contaminants that will affect bond of the membrane.
3. Vacuum clean or clear water wash surfaces and allow to dry completely.

B. Fill voids and control joints with sealant and overcoat with nonflow membrane material. Fill or coat visible shrinkage cracks to minimum 2 inches either side of crack.

C. Use drop cloths or masking as required for protection of adjacent surfaces.

3.03 FLASHINGS-FLUID APPLIED

A. Unless Drawings establish more restrictive requirements, the following minimum requirements apply:

1. Fill construction joint voids at intersections of vertical and horizontal walls with backer rod and sealant in accordance with requirements of membrane manufacturer.
2. Nonreinforced Flashing:
    a. Install nonreinforced flashing at construction joints not subject to movement, at all intersecting surfaces that are structurally and rigidly connected, and at all piping or other penetrations through membraned surface that do not require reinforced flashing.
    b. Apply 50-mil minimum dry film thickness of membrane for 4 inches minimum onto adjacent surfaces.
    c. At intersections of membrane with vertical walls, piping penetrations, and at projections through horizontal membrane, extend flashing coat to a height not greater than finished horizontal surface, with due allowance for installation of sealant work. Trowel a 1-inch-high, 45-degree cant at meeting angle using nonflowing membrane material.
    d. At projections through a vertical membrane, extend flashing coat 4 inches minimum onto penetrating element.
3. Reinforced Flashing:
    a. Apply flashing reinforcement over cracks, expansion and control joints, and at changes of plane where adjacent surfaces are not structurally and rigidly connected and also at penetrations through a membrane surface.
    b. Apply 50-mil dry film thickness embedment coat of membrane to surfaces to be flashed. Extend 6 inches minimum out onto adjacent deck surface.
    c. Embed reinforcement in wet coating. Embedment coating should extend 2 inches beyond reinforcement.
    d. At intersections of membrane with vertical walls, extend embedment coat and reinforcement to a height not greater than finished horizontal surface with due allowance for installation of sealant work. Trowel a 1-inch high, 45-degree cant at meeting angle using nonflowing coating material.

3.04 MEMBRANE

A. Install, following safety and weather conditions required by manufacturer or as modified by applicable rules and regulations of federal, state, and local authorities having jurisdiction.

B. Following manufacturer's instructions, apply membrane material with a calibrated notched squeegee, trowel, or approved spray equipment to produce a 50-mil minimum dry thickness.

C. Extend membrane over previously flashed areas.

D. Use self-leveling membrane material up to a 5 percent slope.

E. Use nonflow membrane material for vertical surfaces and surfaces over a 5 percent slope.

F. Allow membrane to cure overnight. At temperatures less than 75 degrees F and relative humidity less than 50 percent, extend curing time.

3.05 PROTECTION

A. Protect cured vertical membranes exposed to backfilling operations with protection board.

B. Butt all boards; do not overlap.

C. Adhere or bond protection boards to membrane as recommended by membrane manufacturer.

D. Install drainage board as recommended by membrane manufacturer.

3.06 CLEANING

A. Clean stains from adjacent surfaces with toluene, 1-1-1, trichloroethane, xylene, commercial tar remover, or as recommended by the membrane manufacturer.

B. Remove foreign matter from finished membrane surface.

3.07 APPLICATION SCHEDULE

A. Membrane: Apply waterproofing membrane, drainage board if required and protection board to exterior surfaces of cast-in-place concrete structures below finish ground level where shown on Drawings.

END OF SECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C578, C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
   b. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
   c. D1621, Standard Test method For Compressive Properties Of Rigid Cellular Plastics.
   d. D4397, Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer's product literature identifying products proposed for use.
2. Shop Drawings: Provide plan and elevation drawings showing proposed limits of aluminum facing panel and rigid insulation installation. Provide details showing attachment to structure, terminations and joint covers.

1.03 DELIVERY, STORAGE, AND HANDLING

A. On packaging clearly identify manufacturer, contents, brand name, applicable standard, and R-value.

B. Store materials off ground and keep them dry. Protect against weather, condensation, and damage.

PART 2 PRODUCTS

2.01 ALUMINUM FACING PANELS

A. Panels: Aluminum composite panel with a high-density corrugated polyallomer core and painted aluminum faces; 6 mm total thickness.

1. ASTM E84, Class A flame spread rating.
2. Manufacturer and Product (Basis of Design): Laminators Inc.; Alumalite.

B. Joint Finishing System: Finish all aluminum-faced insulation joints using the Dow Chemical T-Rail & J-Channel Closure System. Use tape recommended by manufacturer.

2.02 RIGID INSULATION

A. Extruded Polystyrene (XPS) Foam:

1. ASTM C578, Type IV.
2. Flame Spread: Less than 25 when tested in accordance with ASTM E84.
3. Compressive Strength: Minimum of 25 psi at 10 percent deformation in accordance with ASTM D1621.
4. R-Value per Inch: R-5.
5. Manufacturers and Products:
   a. Kingspan; GreenGuard.
   b. Owens Corning; Foamular 250.

B. Adhesives and Fasteners: As recommended by insulation manufacturer.

2.03 BATT INSULATION AND FASTENERS

A. Fiberglass or Mineral Wool Batts:

1. Batt Insulation Types:
   a. Unfaced Batt Insulation: ASTM C665, Type I, with no vapor retarder. R-values as shown on Drawings.
2. Formaldehyde free.
3. Manufacturers:
   a. CertainTeed Corp.
   b. Owens-Corning Insulating Systems.
   c. Johns Manville.

B. Tape: As recommended by insulation manufacturer.

C. Ventilation Baffles: As recommended by insulation manufacturer for installation between prefabricated steel trusses, CMU block outs, and underside of metal deck.

2.04 VAPOR RETARDER

A. Plastic Sheeting: ASTM D4397, minimum thickness of 10 mils.

B. Sealant and Tape: As recommended by vapor retarder manufacturer.

2.05 ACCESSORIES

A. Insulation for Miscellaneous Voids:

1. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.
   a. Manufacturer and Product: Carlisle; SealTite Pro One Zero.

B. Adhesive for Bonding Insulation: Product compatible with insulation and air and water barrier materials, and with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

PART 3 EXECUTION

3.01 ALUMINUM FACING PANELS OVER RIGID INSULATION

A. Install 2-inch thick rigid insulation overlayed with aluminum facing panel on interior of all concrete vaults and structures unless indicated otherwise.

B. Installation Limits:

1. Bottom of roof slabs, beams, and walls to a minimum depth of 4 feet below finished grade unless noted otherwise on Drawings.
2. Interior faces of hatches, roof panels, and their openings.
3. Do not install behind ladders unless indicated otherwise.

C. Install, in sizes as large as possible, in accordance with manufacturer's recommendations and as specified below:

1. Prepare surfaces in accordance with manufacturer's recommendations.
2. Attach clip strip and J-channel to concrete walls and ceiling using stainless-steel power-driven fasteners.
3. Install so that all rigid insulation surfaces are covered.
4. Butt insulation boards together tightly at joints.
5. Test boards for fit-up prior to application of adhesive.
6. Attach securely in place with manufacturer recommended adhesive and mechanical fasteners (Hilti insulation anchor and fasteners, IDP or IZ type). Adhesive shall be formulated to specifically bond

insulation to steel (hatches and panels) and concrete surfaces, as well as bond the aluminum facing panel to the rigid insulation.

3.02 BATT INSULATION

A. Install in accordance with manufacturer's instructions, as shown on Drawings and as specified below:

1. Install in widths required by framing spacing.
2. Fit tightly to ensure continuous seal.
3. Where electrical outlets, ducts, pipes, vents, or other utility items occur, place insulation on cold weather side of obstruction.
4. Protect installed insulation from tears and other damage.
5. Remove and replace damaged material.
6. Install ventilation baffles as recommended by manufacturer.

3.03 VAPOR RETARDER

A. Install in accordance with the following:

1. Apply over unfaced batt insulation to ceiling framing in sheets as large as possible.
2. Lap joints 6 inches.
3. Seal joints with sealant and tape as recommended by vapor retarder manufacturer.
4. Fit tightly and seal around penetrations.
5. Repair minor tears or holes with tape.
6. Replace sheets with tears or holes, which require more than 6-inch length of tape to repair.

3.04 MISCELLANEOUS VOIDS

A. Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation and to maintain a continuous air barrier using the following materials:

1. Spray Polyurethane Insulation: Apply according to manufacturer's written instructions.

END OF SECTION

SECTION 07 31 10
STONE COATED METAL ROOF SHINGLE, METAL SOFFIT, CEILING, AND SIDING PANELS

PART 1 GENERAL

1.01 SUMMARY

A. Provide formed metal roofing panels with colored stone chip finish.

B. Section Includes:

1. Formed metal roofing panels with colored stone chip finish.
2. Exterior and interior soffit and ceiling panels.
3. Exterior siding panels.
4. Associated metal flashings.

C. Related Sections:

1. Section 06 10 00, Rough Carpentry, for sheathing.
2. Section 07 62 00, Sheet Metal Flashing and Trim, for metal flashing, gutters, and downspouts.
3. Section 07 92 00, Joint Sealants, for field-applied sealants.

1.02 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, finishes, fasteners, accessories, and manufacturers written installation instructions.

B. Shop Drawings: Include roof plans and elevations; sections at gables, ridges, valleys, and eaves; and details of components, accessories, and attachments to other work.

C. Samples for Initial Selection: Manufacturer's color samples consisting of units or sections of units showing the full range of colors, textures, and patterns available.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Conform to applicable building code for roof assembly fire hazard requirements.
2. Conform to building code for minimum wind uplift resistance.

1.04 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A792/A792M, Sheet Steel, Aluminum-Zinc Alloy Coated Steel by the Hot Dip Process, Structural (physical) Quality.
   b. C920, Specification for Elastomeric Joint Sealants.
   c. Fire-Test-Response Characteristics: Provide shingle with fire-test-response characteristics indicated, as determined per test method ASTM E108, Test for Fire Resistance of Roof Covering Materials, for application and slopes indicated.
      1) Fire-Test Exposure: Class A.
2. UL:
   a. 1897 and UL 580, Wind Uplift Resistance of Roof Assemblies.
   b. 2218, Impact Resistance of Prepared Roof Covering Materials.
      1) Impact Resistance: Class 4.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store product in manufacturer's unopened packages with identification labels intact until ready for installation.

B. Store and handle roofing materials to ensure dryness. Store in a dry, well ventilated, weather tight place. Protect from corrosion, staining and traffic and wind damage. Store rolls of felt and other sheet materials on end on pallets or another raised surface.

1.06 WARRANTY

A. Manufacturer's Warranty: Written, transferable, limited warranty signed by roofing systems manufacturer, covering manufacturing defects/excessive granule loss. Refer to warranty for specifics.

1. Warranty Period: Limited Lifetime fully transferable warranty (50-year warranty from date of installation upon transfer to new owner).
2. Wind Warranty: 120 mph winds, full warranty period.
3. Hail Penetration: 2-1/2-inch stone for full warranty period.

PART 2 PRODUCTS

2.01 METAL ROOF SHINGLES

A. Manufacturers and Products:

1. Basis of Design: Westlake Royal Roofing Solutions, Granite Ridge.
   a. Contact Information: 2801 Post Oak, Suite 600 Houston, TX 77056, telephone (800) 658-8004, Website: www.westlakeroyalroofing.com.
2. "Or-equal."

B. Materials:

1. Metal Shingle: Formed interlocking panels resembling heavyweight dimensional shingles.
   a. Material: Rolled and pressure formed, aluminum-zinc alloy coated steel with two vertical ribs forming two flat steps, each of which shall have raised and lowered pan sections.
   b. Finish: Ceramic coated colored stone chip finish.
   c. Thickness: 0.0179 inch.
   d. Steel: Grade 37.
   e. Size: 15-1/2 inches wide by 45-3/4 inches long.
   f. Exposure: 14-3/8 inches wide by 41-3/4 inches long.
   g. Weight: 150 pounds per square.
   h. Color: As indicated on Color List on Drawings.
2. Flashings:
   a. Trim to be of same material, profile and color as indicated on Color List on Drawings:
      1) Fascia Metal: Starter Clip with Drip Edge, Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to fit along the leading edge of roof panels at eave/fascia.
      2) Rake / Gable Channel: Shingle Rake/Gable Channel, Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to match roofing material, finish and color to be applied along rakes and gables.
      3) Side Flashing: Side Flashing, Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to match roofing material, color, and finish to be applied along roof-to-wall when a counter flashing is needed.
      4) Roof-to-Wall Flashing: Channel - Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to flash vertical roof surface transitions.
         a) Finish: Paint to match roofing material.

5) Pipe Jack Flashing: Galvanized or Aluminum-Zinc Alloy Coated Steel, 0.0165 inches. Clean, prime and paint to match roof material.
6) Underpan: Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to counter flash roof penetrations matching panel material profile.

3. Ridge: Shingle ridge covers matching roofing material, color, and finish.
   a. Ridge: Shingle Ridge Aluminum-Zinc Alloy Coated Steel sheet, 0.0165 inches. Pressure formed to match roofing material, color, and finish to be applied along ridges.
   b. Screws: Minimum No. 9 hex (1/4-inch diameter) by 1-1/2 inches long minimum, corrosion resistant, color coordinated to match the panels. Installation per manufacturers recommended installation instructions.

2.02 METAL SOFFIT AND CEILING PANELS

A. General: Provide factory-formed metal soffit panels designed to be field-assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fastening and factory-applied sealant inside laps; included accessories for a complete, weathertight installation.

B. Clips:

1. Panel clips with spring tab at one end and hold-down clamp at other end, sized to fit panels.
2. Material: 16-gauge formed steel, galvanized in conformance with ASTM A653.

C. Panels:

1. Material: Aluminum-zinc alloy coated sheet 24-gauge minimum metal thickness.
2. Finish: Premium fluoropolymer coating system; minimum 70 percent Kynar 500, 1.0-mil minimum total dry film thickness.
3. Color: As selected from manufacturer's standard color range or as indicated in Exterior Finish Schedule on Drawings.
4. Panel Coverage: 12 inches.
5. Panel Height: 1.5 inches.
6. Profiles:
   a. Interior – Flush Metal Ceiling Panels: Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges with flush joint between panels.

b. Exterior – Vented Metal Soffit Panels: Vented panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges with flush joint between panels.

7. Manufacturers and Products:
   a. Berridge Manufacturing Co.; FW-12.
   b. MBCI; Artisan.
   c. AEP-Span; Prestige (R-2) 12 panels.

2.03 METAL SIDING PANELS

A. General: Provide field-assembled preformed metal wall panels with manufacturer's standard concealed fasteners.

B. Panels:

1. Material: Aluminum-zinc alloy coated sheet 24-gauge minimum metal thickness.
2. Finish: Premium fluoropolymer coating system; minimum 70 percent Kynar 500, 1.0-mil minimum total dry film thickness.
3. Color: As selected from manufacturer's standard color range or as indicated in Exterior Finish Schedule on Drawings.
4. Panel Coverage: 8 inches.
5. Pattern:
   a. Panel Height: 7/8 inch.
   b. 5 5/8-inch rib.
   c. 2-inch reveal.
6. Texture: Standard stucco embossed.

C. Manufacturers and Products:

1. Berridge Manufacturing Co.; HS-8.
2. MBCI.; Masterline 16®.
3. AEP-Span.; PC50-12.

2.04 ACCESSORIES

A. Sheet Metal Materials:

1. Aluminum-Zinc Alloy Coated Steel Sheet: ASTM A792/A792M, Class AZ50 coating designation; minimum Grade 37.

B. Underlayment: ASTM D226, Type II, E108 Class A; fire resistant, thermal insulating & reflective roof underlayment.

1. Manufacturer and Product: Westlake Royal Roofing Solutions; Sol-R-Skin® Blue.

C. Ice & Water Shield: ASTM D1970; self-adhering, high strength, non-woven polyester surface; 60 mils nominal thickness. Provide primer when recommended by underlayment manufacturer.

1. Manufacturer and Product: Westlake Royal Roofing Solutions; MetalSeal HT.

D. Sealant: One-part elastomeric polyurethane sealant as recommended in writing by shingle manufacturer. Where sealant will be exposed, provide in color matching roofing material. Standard: ASTM C920-86.

E. Fasteners:

1. Screws: Minimum No. 9 hex (1/4 inch diameter) by 1-1/2 inches long minimum, corrosion resistant, black or color coordinated to match the panels where visible.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrate and conditions for compliance with requirements for maximum moisture content, soundness of framing, and other conditions affecting performance of metal roofing. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Clean substrate of any projections and substances detrimental to metal panel roofing. Cover knotholes or other minor voids in substrate with sheet metal flashing secured with roofing nails.

B. Coordinate installation of metal panels with flashing and other adjoining work to ensure proper sequencing. Do not install roofing until vent stacks and other penetrations through roofing have been installed, are securely fastened and flashing is in place.

3.03 INSTALLATION

A. General: Comply with manufacturer's written instructions for products and applications indicated, unless more stringent requirements apply.

B. Ice and Water Shield: Apply over entire roof sheathing substrate to receive metal shingles, including at eaves, ridges, edges, and around projections through roof.

C. Underlayment:

1. Install underlayment over ice and water shield as recommended by metal roof panel manufacturer.
2. Apply underlayment single-ply lapped shingle fashion, 3 inches at head and 6 inches at sides.
3. Install no more than can be covered by metal roofing or other approved protection, in same day.
4. Use adhesive for temporary anchorage, where possible, to minimize use of mechanical fasteners under metal roof panels.

D. Flashing: Install as indicated on approved submittals and in accordance with manufacturer's written instructions.

E. Shingle Panels: Install shingles, accessories, flashing, and ridge level and plumb. Use fasteners per above specifications.

1. Install each shingle panel left to right in accordance with manufacturer's instructions. Do not create a pattern.
2. The right side of each panel must be pushed into position to engage the Side-Lap locking mechanism.
3. Fasten each panel with minimum 5 fasteners horizontally along the back flange of each panel at pre-punched tabs. Review manufacturer's instructions for fastener placement.
4. First course of panels positioned at eave will clip into Starter Clip with Drip Edge.

F. Ridge: Install Shingle Ridge along ridges as indicated on approved submittals and in accordance with manufacturer's written instructions. Bend and fold exposed ends of ridges and neatly cap with an end cap or a piece of similar material.

G. Metal Soffit and Ceiling Panels:

1. Provide full width of soffit or ceiling. Install perpendicular to support framing. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of openings and joints.
2. Provide back support for panels at mitered corners.

H. Metal Siding Panels:

1. Provide full width as indicated on Drawings. Install perpendicular to support framing. Flash and seal panels with weather closures where metal siding panels meet soffits and at perimeter of openings and joints.

2. Align bottom of wall panels and fasten panels with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.

3.04 CLEANING AND PROTECTION

A. Damaged Units: Replace panels and other components of the work that have been dented damaged or have deteriorated beyond successful repair by finish touchup with acrylic coating and stone chip granules.

B. Cleaning: After completing installation, remove any debris from the roof.

C. Foot Traffic: Avoid walking on side laps.

END OF SECTION

SECTION 07 54 23
THERMOPLASTIC MEMBRANE ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes insulation, membrane roofing, coverboard, base flashings, and counter flashings.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Wood Protection Association (AWPA): U1, Use Category System: User Specification for Treated Wood.
2. ASTM International (ASTM):
   a. C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
   b. C728, Standard Specification for Perlite Thermal Insulation Board.
   c. C1289, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
   d. D41, Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
   e. D312, Standard Specification for Asphalt Used in Roofing.
   f. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
   g. D471, Standard Test Method for Rubber Property—Effect of Liquids.
   h. D573, Standard Test Method for Rubber—Deterioration in an Air Oven.
   i. D751, Standard Test Methods for Coated Fabrics.
   j. D1149, Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment.
   k. D1204, Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
   l. D4601, Standard Specification for Asphalt-Coated Glass Fiber Base Sheet Used in Roofing.
   m. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   n. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
   o. E108, Standard Test Methods for Fire Tests of Roof Coverings.

p. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.
q. E408, Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques.
r. E1980, Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

3. FM Global (FM):
   a. DS 1-28, Design Wind Loads.
   b. DS 1-29, Roof Deck Securement and Above-Deck Roofing Components.
   c. 4450, Approval Standard for Class I Insulated Steel Deck Roofs.
4. International Code Council (ICC): International Building Code (IBC).
5. Intertek Testing Services (Warnock Hersey Listed) (WH), Certification Listings.
6. National Roofing Contractors Association: NRCA Roofing and Waterproofing Manual.
7. Single Ply Roofing Institute (SPRI): ES-1, Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems.
8. UL:
   a. 790, Standard Test Methods for Fire Tests of Roof Coverings.
   b. 1256, Fire Test of Roof Deck Constructions.
   c. 1897, Uplift Tests for Roof Covering Systems.
9. U.S. Department of Defense Military Standard (MIL): 3010, Test Procedures for Packaging Materials.
10. U.S. Environmental Protection Agency (EPA): ENERGY STAR - ENERGY STAR Voluntary Labeling Program.

1.03 DESIGN REQUIREMENTS

A. Low Slope Membrane Roof Edge Securement: Conform to SPRI ES-1 for wind speeds determined from applicable edition of ICC IBC code.

1.04 PERFORMANCE REQUIREMENTS

A. Uplift Resistance: UL 1897; 90 psf uplift pressure resistance.

B. Fire/Windstorm Classification: Class NCA.

C. Hail Resistance: MH.

D. Exterior Fire-Test Exposure: Class A.

1.05 SUBMITTALS

A. Action Submittals:

1. Layout of tapered insulation.
2. Project-specific details of roof penetrations and perimeter conditions.
3. Layout and details of fully adhered system.
4. List of materials proposed for use; include roofing materials, accessories, insulation, and fasteners.
5. Manufacturer's specifications selected for use; include description of complete system from deck up.
6. Documentation that anchoring system meets uplift requirements.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Manufacturer's installation instructions.
3. Letter or other documentation from roofing materials manufacturer stating that installer has been trained and approved to apply roof system.
4. Sample copy of guarantee to be provided.
5. Record of Preroofing Conference.
6. Inspection reports for inspections conducted by membrane manufacturer's representative; include written instructions or recommendations as conditions to special guarantee.
7. Operation and Maintenance Data:
   a. As specified in Section 01 78 23, Operation and Maintenance Data.
   b. Include sketches where applicable, recommendations for periodic inspection, care, and maintenance.
   c. Identify common causes of damage with instructions for temporary patching until permanent repair can be made.
8. Manufacturer's Certificate of Proper Installation per Section 01 43 33, Manufacturers' Field Services, (or alternately, test results or calculations) that assure item's and its anchorage's design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.06 QUALITY ASSURANCE

A. Perform Work in accordance with NRCA Roofing and Waterproofing Manual.

B. Roof Assembly Fire Classification: Minimum Class A when tested in accordance with ASTM E108 or UL 790.

1. Roof Assembly with Foam Insulation: Passes FM 4450 or UL 1256.

C. Surface Burning Characteristics:

1. Foam Insulation: Maximum 75/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

D. Apply label from agency approved by authority having jurisdiction to identify each roof assembly component.

1.07 QUALITY CONTROL

A. Installer Qualifications:

1. Trained and approved by roof membrane manufacturer.
2. Experience: 3 years, minimum, in the installation of the specific roofing and flashing system specified.

B. Materials, including insulation used in roofing system shall be furnished by or approved by manufacturer whose roofing system is selected for use.

1.08 PREROOFING CONFERENCE

A. Conference Requirements:

1. Attendees: Engineer, roofing installer, roofing manufacturer, installers of related Work, and other entities concerned with roofing performance included, where applicable, Owner's insurer, test agencies, governing authorities, and Owner.
2. Agenda: Follow outline in NRCA's Waterproofing Manual. Include acceptability of deck, roofing system, materials, manufacturer's specifications selected, flashing details, roof guarantee, and protection of furnished roofing system.
3. Documentation: Record discussion and agreements. Furnish copy to each attendee invited.

B. Membrane manufacturer's inspections as required to meet conditions of guarantee.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in their original, unopened containers, clearly labeled with manufacturer's name, brand name, and such identifying numbers as are appropriate.

B. Storage:

1. Store materials at temperatures between 60 degrees F and 80 degrees F. Should they be exposed to lower temperatures, restore to 60 degrees F prior to use.
2. Store rigid roof insulation materials on clean, raised platform.
3. Do not store uncured flashing membrane on roof or at temperatures exceeding 75 degrees F.

C. Protect materials against wetting, moisture absorption, and construction traffic.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Weather: Do not install roofing during precipitation or when it is probable.

B. Temperature:

1. Install roofing when ambient temperature is 50 degrees F or above.
2. When temperature is below 50 degrees F, install only with approval or and under supervision of membrane manufacturer.

1.11 COORDINATION

A. Coordinate Work with installation of associated roof penetrations and metal flashings, as Work of this section proceeds.

1.12 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of roofing membrane, flashing, insulation, and accessories found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Coverage and Conditions:

1. Costs for repairs required to maintain roofing system, flashing, expansion joint covers, and roof vents in watertight condition.
2. Natural deterioration of roofing system as a result of ordinary wear and tear by elements.
3. Defects as a result of faulty materials or workmanship during application.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fully Adhered TPO Roofing:

1. Johns Manville; ST8RA-C/I, 80-mil membrane.
2. Firestone Building Products Co.; Ultraply TPO.
3. GenFlex Roofing Systems; TPO.

2.02 ROOFING SYSTEM

A. Roofing system shall meet these Specifications, and approval and warranty of membrane manufacturer to provide a fully adhered complete TPO system including the following:

1. Membrane.
2. Roof insulation.
3. Cover board.
4. Flashing.
5. Adhesives.
6. Fasteners.
7. Accessory materials.

2.03 MEMBRANE MATERIALS

A. Reinforced thermoplastic polyolefin sheet, 0.080 inch thick with the following properties:

Properties	Test Method	Specification
Thickness Tolerance	ASTM D751	Plus or minus 10%
Breaking Strength (min)	ASTM D751, Grab Method	300 pounds
Elongation at Break	ASTM D412	30 %
Tear Strength (min)	ASTM D751	60 pounds

Properties	Test Method	Specification
Ozone Resistance	ASTM D1149, 70 hours at 100 degrees F	No cracks or other affect
Heat Aging	ASTM D573, 28 days at 212 degrees F retention of tensile	Maintain 100% of original breaking strength
Water Absorption (change in mass)	ASTM D471, 158 degrees F for 7 days	1%
Hydrostatic Resistance (min)	ASTM D751, Method A	430 psi
Puncture Resistance	MIL Std 3010	380 pounds
Dimensional Stability (% change max.)	ASTM D1204	+ 0.4%

B. Membrane Sheet Size: Minimum width 60 inches by length of largest sheet possible, determined by Project conditions.

C. Color: White.

D. Energy and Environment:

1. Roof Surface: Minimum solar reflectance index (SRI) for 75 percent of roof area, in accordance with ASTM E1980. Emissivity in accordance with ASTM E408.
   a. ENERGY STAR: Reflectivity 0.78, emissivity 0.90.

2.04 ACCESSORY MATERIALS

A. Adhesives and Fasteners:

1. Surface Conditioner: Compatible with membrane.
2. Membrane cover board, and insulation adhesives and fasteners as recommended by membrane manufacturer.
3. Thinner and Cleaner: As recommended by adhesive manufacturer, compatible with sheet membrane.

B. Flashing:

1. 0.080-inch roofing membrane.
2. Provide unreinforced 0.070-inch-thick roofing membrane for field fabricated vent stacks, pipes, and corners.

C. Primer: ASTM D41 Asphalt.

D. Asphalt: ASTM D312, Type III steep asphalt.

E. Roofing Felt: ASTM D4601, Type IV or VI asphalt-coated glass fiber mat.

F. Nailers: Preservative treated wood as specified in Section 06 10 00, Rough Carpentry.

1. Waterborne salt preservatives; AWPA U1.
2. Apply two brush coats of same preservative used in original treatment to sawed or cut surfaces of treated lumber.
3. Minimum Grade: Standard of Better, or Stud Grade.

2.05 RIGID ROOF INSULATION BOARD

A. Average Aged R-value for Total Thickness of Rigid Insulation: Minimum R- 15.

B. Any one of the following insulation materials may be used on this Project provided roofing materials manufacturer will guarantee roofing system.

1. Extruded Polystyrene Board:
   a. ASTM C578, Type IV.
   b. Minimum Size: 2 feet by 4 feet.
   c. Manufacturers and Products:
      1) Owens Corning; Foamular 250.
      2) Dow chemical Co.; Styrofoam RM.

2.06 COVER BOARD

A. Manufacturers and Products:

1. Johns Manville; Duraboard, Nailboard, Invinsa Roof Board, ENRG 3-Plus.
2. Wood Fibers Industries (USG); StructoDek.

2.07 ROOF WALKWAY

A. Manufacturers and Products:

1. Johns Manville; TPO Walkpad.
2. Firestone Building Products Co.; Ultraply™ Walkway Pad.
3. GenFlex Roofing Systems; TPO Walkway Pad.

PART 3 EXECUTION

3.01 PREPARATION

A. Surfaces to be adhered shall be dry before and throughout entire application.

B. Notify Engineer and manufacturer's representative at least 48 hours before installation of insulation, membrane, and roofing system.

C. Inspection:

1. Verify work of other trades that penetrates roof deck or requires roof access has been completed.
2. Ensure deck is firm, dry, free of foreign material, and reasonably smooth.
   a. Differential height between adjacent roof deck members of more than 1/8 inch is not acceptable.
   b. Repair joints greater than 1/4 inch wide.
3. Report immediately to Engineer cracks, breaks, holes, or other unusual irregularities in surface.
4. Cover rough surface that would cause damage to membrane with protection board.

3.02 NAILERS:

1. Install wooden nailers at locations required by roofing manufacturer and as shown on Drawings.
2. Anchor nailer with a suitable fastener with minimum withdrawal resistance to meet specified design loads.
3. Stagger fasteners 6 inches on center within 8 feet of outside corner and 12 inches on center along other perimeter areas.
4. Nailer Thickness: Choose to match top surface of adjacent construction.

3.03 INSTALLATION

A. In accordance with membrane manufacturer's standard details for flashing and termination conditions not shown.

B. In accordance with Article Performance Requirements for uplift conditions.

C. In accordance with applicable recommendations of FM DS 1-29.

D. Insulation:

1. Keep insulation dry before and during application.
2. Install rigid insulation where and to thickness necessary for R-value indicated in two or more layers, staggering joints.
3. Lay insulation with longest dimension perpendicular to direction of membrane seams with joints staggered over roof area to be covered.
4. Butt boards as closely as possible with no gaps over 1/4 inch.
5. Mechanically fasten insulation to deck following roofing membrane manufacturer's instructions.
6. Do not install more insulation each day than can be covered with membrane before end of day or start of inclement weather.

E. Cover Board:

1. Install cover board over rigid roof insulation with longest dimension perpendicular to membrane seams with joints staggered over roof area to be covered.
2. Fasten or adhere cover board to substrate in accordance with roofing membrane manufacturer's instructions.

F. Membrane:

1. Install membrane and flashing in accordance with manufacturer's recommendations and instructions.
2. Heat weld joints following manufacturer's instructions.
3. Fully adhere membrane to cover board.

G. Flashing:

1. Install perimeter, curb, drains, and other detail flashing as shown on manufacturer's standard detail drawings and as follows:
   a. Heat weld flashing to membrane and attach to other surfaces following manufacturer's instructions.
   b. Install pipe flashing, and roof drains in accordance with manufacturer's standard details and instructions.

H. Temporary and Night Seals:

1. Provide water cutoffs under the following circumstances:
   a. Where and when a danger exists that water caused by precipitation may get under new roofing membrane.
   b. At end of each day.
2. Make by securely setting end of membrane in 6-inch-wide continuous application of cement and weight adhered edge to prevent displacement of cutoff.

3. Remove temporary water cutoffs prior to proceeding with next work period by cutting off and disposing of portion of membrane that has been in contact with cement.

I. Walkways: Adhere to membrane with membrane manufacturer's bonding adhesive.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and Certification of Proper Installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.05 CLEANING

A. Remove spots and smears of asphalt or other material from flashings, and other surfaces not intended to be coated with such material. During removal, do not damage surfaces. Use solvents, if necessary, to clean surfaces.

3.06 PROTECTION

A. Limit traffic of personnel and equipment on completed roof to that deemed essential for completion of Project.

END OF SECTION

SECTION 07 62 00
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
   e. B32, Standard Specification for Solder Metal.
   f. C920, Standard Specification for Elastomeric Joint Sealants.
   g. C1311, Standard Specification for Solvent Release Sealants.
   h. D1187/D1187M, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   i. D4586/D4586M, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
2. FM Global (FM): Loss Prevention Data Sheet 1-49, Perimeter Flashing.
3. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 1013, Architectural Sheet Metal Manual.

1.02 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Fabricate and install roof edge flashing capable of resisting the forces according to recommendations in FM Loss Prevention Data Sheet 1-49.

C. Components and Cladding Wind Pressure: 90 pounds per square foot uplift at all locations.

D. Thermal Movements:

1. Provide sheet metal flashing and trim that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures for preventing buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects.
   a. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.
2. Provide clips that resist rotation and avoid shear stress because of sheet metal and trim thermal movements.
3. Base engineering calculation on surface temperatures of materials because of both solar heat gain and nighttime-sky heat loss.

E. Water Infiltration: Provide sheet metal flashing and trim that does not allow water infiltration to building interior.

1.03 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA 1013. Conform to dimensions and profiles shown unless more stringent requirements are indicated.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Show joints, types and location of fasteners, and special shapes.
   b. Catalog data for stock manufactured items.
2. Samples: Color Samples for items to be factory finished.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Inspect for damage, dampness, and wet storage stains upon delivery to Site.

B. Remove and replace damaged or permanently stained materials that cannot be restored to like-new condition.

C. Carefully handle to avoid damage to surfaces, edges, and ends.

D. Do not open packages until ready for use.

E. Store materials in dry, weathertight, ventilated areas until immediately before installation.

1.06 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction or, at the option of the Owner, removal and replacement of factory-applied fluoropolymer coating, finish, and accessories found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

B. Conditions:

1. Finish: No cracking, blistering, flaking, chipping, checking, chalking, peeling, or fading.
2. All Components: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 METAL

A. Prefinished Galvanized Steel Sheet: ASTM A924/A924M, Grade A or ASTM A653/A653M, G90 zinc coating; 24-gauge (0.02-inch) core steel, shop prefinished with fluoropolymer coating (Kynar polyvinylidene fluoride resin) coating; color as selected from manufacturer's standard color range.

B. Stainless Steel: ASTM A666, Type 316, soft temper; No. 2D, dull finish, 0.018 inch thick, unless otherwise shown.

C. Building 20 Flashings: Refer to Section 07 31 10, Stone Coated Metal Roof Shingle Metal Soffit, Ceiling, and Siding Panels.

2.02 REGLETS AND COUNTERFLASHING

A. For Concrete:

1. Stainless steel, 0.015 inch.
2. Manufacturers and Products:
   a. Fry Reglet Corp.; Fry Springlok Type CO and Springlok Flashing.
   b. Cheney Flashing Co.; Type A reglet and Snap Lock Cap Flashing.

2.03 PREFABRICATED METAL SYSTEMS

A. Coping System:

1. Snap-on system, stucco embossed pattern aluminum, 0.050-inch minimum thickness.
2. Include ancillary items, such as mitered and welded corners, and end caps, where shown and as required for complete system.
3. Side lengths as shown on Drawings.
4. Manufacturers and Products:
   a. W.P. Hickman Co.; Permasnap Coping.
   b. IMETCO; ES-C Sloped Coping.
   c. Johns Manville; Presto Lock Coping System.

B. Finish: Factory finished with full strength fluoropolymer coating (Kynar polyvinylidene fluoride resin) in color as selected.

2.04 DOWNSPOUTS, GUTTERS, SCUPPERS, AND CONDUCTOR HEADS

A. Same metal and thickness as Prefinished Galvanized Steel Sheet.

2.05 SILL PAN FLASHING AT DOORS AND LOUVERS

A. Stainless Steel concealed: 0.0188-inch thick. Type 316 with smooth, flat surface.

B. Stainless Steel exposed to view: 0.0188-inch thick. Type 316 with embossed surface.

2.06 ANCILLARY MATERIALS

A. Solder: ASTM B32, alloy composition Sn 50 and Sn 60 for stainless steel.

B. Soldering Flux: ASTM B32, Type RA.

C. Sealing Tape: Polyisobutylene sealing tape.

D. Isolation Paint: ASTM D1187/D1187M, asphalt.

E. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil thick minimum polyester.

F. Plastic Roof Cement: ASTM D4586/D4586M, Type II.

G. Elastomeric Sealant: ASTM C920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

H. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

I. Fasteners:

1. Galvanized Steelwork: Steel, galvanized per ASTM A153/A153M or stainless steel fasteners.
2. Stainless Steelwork: Stainless steel.

J. Flexible Flashing (self-adhering)

1. Locations: Parapets, doors, and other concealed locations.
2. Thickness: 40 mil.
3. Manufacturer and Product (Basis of Design): Henry a Carlisle Company; Fortiflash®.

2.07 FABRICATION OF FLASHING

A. Field measure prior to fabrication.

B. Fabricate in accordance with SMACNA 1013 that applies to design, dimensions, metal, and other characteristics of item indicated.

1. Counter Flashing Systems: Figure 4-3.

C. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.

D. 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.

E. Seams:

1. Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams.

F. Reinforcements and Supports: Provide same material as flashing unless other material is shown. Steel, where shown or required, shall be galvanized or stainless.

G. Rigid Joints and Seams: Make mechanically strong. Solder galvanized and stainless steel metal joints. Do not use solder to transmit stress.

H. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

I. 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 butyl sealant concealed within joints.

J. Fabricate sheet metal in 10-foot maximum lengths, unless otherwise indicated.

K. Provide watertight closures at exposed ends of counterflashing.

L. Fabricate corners in one-piece with legs extending 30 inches each way to field joint. Lap, rivet, or solder corner seams watertight. Apply sealant if necessary.

M. Neutralize soldering flux.

N. Solvent clean sheet metal. Surfaces to be in contact with roofing or otherwise concealed shall be coated with isolation paint.

O. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

P. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

1. Thickness: As recommended by SMACNA 1013 and FM Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

2.08 FABRICATION OF DOWNSPOUTS, GUTTERS, SCUPPERS, AND CONDUCTOR HEADS

A. Form downspouts and gutters in maximum lengths as practicable to sizes and shapes indicated on Drawings:

1. Telescope end joints 1-1/2 inches and lock longitudinal joints of downspouts.
2. Provide elbows at bottom where downspouts empty onto splash blocks.

B. Form scuppers and conductor heads to shapes and sizes indicated on Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify roof hatch openings and vents through roof are solidly set and reglets in place.

B. Verify nailing strips and blocking are properly located.

C. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

A. Flashing:

1. General:
   a. Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA 1013.
   b. Provide concealed fasteners where possible, set units true to line, and level as indicated.
   c. Install work with laps, joints, and seams that will be permanently watertight.
2. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FM Loss Prevention Data Sheet 1-49 for specified wind zone and as indicated.
   a. Interlock bottom edge of roof edge flashing with continuous cleats anchored to substrate at 16-inch centers.
3. Isolate metal from wood and concrete and from dissimilar metal with isolation tape or two coats of isolation paint.
4. Use only stainless steel fasteners to connect isolated dissimilar metals.
5. Joints: 10-foot maximum spacing and 2-1/2 feet from corners, butted with 3/16-inch space centered over matching 8-inch-long backing plate with sealing tape in laps.
6. Set flanges of flashings and roof accessories on continuous sealing tape or in plastic roof cement on top of envelope ply of roofing. Nail flanges through sealing tape and at 3-inch maximum spacing. Touch up isolation paint on flanges.
7. Joints, Fastenings, Reinforcements, and Supports: Sized and located as required to preclude distortion or displacement because of thermal expansion and contraction.
8. Provide continuous holddown clips at counterflashing.
9. Conceal fastenings wherever possible.

10. Set flashing and sheet metal to straight, true lines with exposed faces aligned in proper plane without bulges or waves.

B. Prefabricated Metal Systems:

1. Follow system manufacturer's printed instructions and provide as shown on Drawings.
2. Place color variations in pieces so no extremes are next to each other.

C. Downspouts, Gutters, Scuppers, and Conductor Heads:

1. Anchor downspouts to wall with straps of same material as downspouts. Install downspouts to be 1 inch away from walls. Fasten to walls at top, bottom and at intermediate points not to exceed 5 feet on center.
2. Install gutters, scuppers, and conductor heads as indicated on Drawings.

3.03 FINISH

A. Exposed Surfaces of Flashing and Sheet Metalwork: Free of dents, scratches, abrasions, or other visible defects, and clean and ready for painting where applicable.

3.04 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder and sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 70 01
ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   b. D4586, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
2. Occupational Safety and Health Administration (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings of each item specified showing materials, details, flashing, anchorage, and relation to adjacent structure.
2. Catalog cuts of each item specified item.

1.03 SEQUENCING AND SCHEDULING

A. Coordination: Schedule and coordinate work of this section with work of Section 07 31 10, Stone Coated Metal Roof Shingle, Metal Soffit, Ceiling, and Siding Panels, Section 07 54 23, Thermoplastic Membrane Roofing, and Section 07 62 00, Sheet Metal Flashing and Trim.

PART 2 PRODUCTS

2.01 ROOF HATCHES

A. Material: Aluminum, 11-gauge with factory-insulated curb and cover.

B. Size: 3 feet by 2.5 feet.

C. Roof Hatch Safety Railing:

1. Rigid galvanized steel self-closing gate meeting OHSA 1910.29.
2. Material: 1.66-inch O.D. galvannealed steel tubing.
3. Finish: Safety yellow powder coat paint.
4. Hardware: Zinc-plated steel nuts, bolts, and washers and 3/16-inch ASTM proof coil chain and hoops for securing.

D. Manufacturers and Products:

1. Bilco; S-50 with Bil-Guard 2.0.
2. Babcock-Davis; B-RHA Series with BSRCAY36x30FG.
3. JL Industries; RHA-1 with RHT-1-STH.

2.02 ROOF VENTS

A. Steep Slope Roof - Metal Dome with screen.

1. Opening Size: 12-1/2 inches by 12-1/2 inches.
2. Free Area: 144 square inches.
3. Base Dimension: 24 inches by 24 inches.
4. Ventilation Capacity: 300 square feet each.

B. Manufacturer and Product (Basis of Design): Owens Corning (Dreamhome Restoration, LLC) VTSG-144.

2.03 ANCILLARY MATERIALS

A. Isolation Paint: ASTM D1187, asphalt.

B. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil-thick minimum polyester.

C. Plastic Roof Cement: ASTM D4586, Type II.

D. Fasteners: Stainless steel of type required.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces and structures to receive the Work of this section.

B. Take measurements at Site and fabricate work to suit. No changes shall be made in supporting structure to accommodate this Work.

3.02 INSTALLATION

A. General:

1. Install roof specialties and accessories as detailed in approved shop drawings and in conformance with manufacturer's instructions, recommendations, and standards.
2. Factory Finished Units: Place color variations in pieces so no extremes are next to each other.
3. Make Work weathertight and free of expansion and contraction noise.

4. Maintain separation between aluminum surfaces and concrete or dissimilar metals with isolation paint or with isolation tape.

B. Roof Hatches: Install to operate freely and not rattle when closed or open.

C. Roof Vents: Install in accordance with roof vent manufacturer's instructions.

END OF SECTION

SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C661, Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer.
   b. C834, Standard Specification for Latex Sealants.
   c. C920, Standard Specification for Elastomeric Joint Sealants.
   d. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Surface preparation instructions. Indicate where each product is proposed to be used.
2. Samples: Material proposed for use showing color range available.

B. Informational Submittals:

1. Installation instructions.
2. Documentation showing applicator qualifications.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum of 5 years' experience installing sealants in projects of similar scope.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

1.05 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction or, at the option of the Owner, removal and replacement of Work specified in this section found defective during a period of 3 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Conditions: No adhesive or cohesive failure of sealant.

C. Sealed Joints: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

A. Characteristics:

1. Uniform, homogeneous.
2. Free from lumps, skins, and coarse particles when mixed.
3. Nonstaining, nonbleeding.
4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
5. Immersible may be substituted for nonimmersible provided all other specified requirements are met.

B. Color: Unless specifically noted, match color of the principal material adjoining area of application.

C. Type 1—Silicone, Nonsag, Nonimmersible:

1. Silicone base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of withstanding movement up to 50 percent of joint width.
3. Manufacturers and Products:
   a. Dow Corning Corp.; No. 790.
   b. General Electric; Silpruf SCS2000.

D. Type 2—Multipart Polyurethane, Self-leveling, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade P, Class 25.
2. Capable of being continuously immersed in water.

3. Manufacturers and Products:
   a. BASF; MasterSeal, SL-2.
   b. Pecora Corp.; Urexspan NR-200.
   c. Tremco; THC-900/901.
   d. Sika Chemical Corp.; Sikaflex 2c SL.

E. Type 3—Multipart Polyurethane, Nonsag, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora; DynaTrol II.
   b. Tremco; Dymeric 240.
   c. BASF; MasterSeal NP-2.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

F. Type 4—Multipart Polyurethane, Nonsag, Nonimmersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Manufacturers and Products:
   a. BASF; MasterSeal NP-2.
   b. Pecora Corp.; DynaTrol II.
   c. Tremco; Dymeric 240.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

G. Type 5—One-part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. BASF; MasterSeal, SL-1.
   b. Tremco; Vulkem 45.
   c. Sika Chemical Corp.; Sikaflex 1c SL.

H. Type 6—One-part Polyurethane, Nonimmersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Manufacturers and Products:
   a. Pecora Corp.; Dynatrol 1 XL.
   b. Tremco; Dymonic.
   c. BASF; MasterSeal, NP-I.

I. Type 7—Multipart Polysulfide, Immersible:

1. Polysulfide base, two-component, chemical curing; ASTM C920, Type M, Grade P or NS, Class 25.
2. Capable of being continuously immersed in water.
3. For use above grade and below grade.
4. Manufacturers and Products:
   a. W. R. Meadows; Deck-O-Seal Gun Grade, two-part.
   b. BASF; MasterSeal, two-part Polysulfde.

J. Type 8—One-part Polysulfide, Nonsag, Nonimmersible:

1. Polysulfide base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 12 1/2.
2. Capable of withstanding movement up to 20 percent of joint width.
3. Manufacturer and Product: W. R. Meadows; Deck-O-Seal, one-part.

K. Type 9—One-part Acrylic Terpolymer, Nonsag, Nonimmersible:

1. Acrylic base, single-component, solvent curing; ASTM C834 nonsag.
2. Capable of withstanding movement up to 7.5 percent of joint width; Shore “A” hardness of 55 maximum.
3. Manufacturer and Product: Tremco; Mono 555.

L. Type 12—One-part Polycarbonate, Immersible:

1. Polycarbonate base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturer and Product: Pro-Seal Products, Inc.; Pro-Seal 34.

M. Type 13—Tape Sealant:

1. Compressible polyurethane foam impregnated with polybutylene or polymer-modified asphalt.
2. Color: Black.
3. Size: 3/4 inch wide by length required by expanded thickness recommended by manufacturer for particular application.
4. Manufacturers and Products:
   a. Emseal Joint Systems, Ltd.; AST—High Acrylic.
   b. PARR Technologies; PARR Sealant EP-7212-T.

2.02 BACKUP MATERIAL

A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16 inch wide.

C. Manufacturers and Products:

1. BASF; MasterSeal 920 and 921 (Closed-cell Backing Rod).
2. Tremco; Closed-cell Backing Rod.
3. Pecora Corporation; Green Rod.
4. W.R. Meadows; Cera-Rod and Kool-Rod.

2.03 ANCILLARY MATERIALS

A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 GENERAL

A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.

B. Install joint sealants in accordance with ASTM C1193.

C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.

D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

E. Use joint sealant as required for the applicable application and as follows:

Joint Size	Sealant Type
Less than 1"	1, 2, 3, 4, 5, 6, 7, 8, 9, or 12
Less than 2"	1, 2, 3, 4, or 7
Over 2"	Follow manufacturer’s recommendation

3.02 PREPARATION

A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.

B. Surfaces to be sealed shall be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.

1. Mask adjacent surfaces where necessary to maintain neat edge.
2. Starting of work will be construed as acceptance of subsurfaces.
3. Apply primer to dry surfaces as recommended by sealant manufacturer.

C. Verify joint shaping materials and release tapes are compatible with sealant.

D. Examine joint dimensions and size materials to achieve required width/depth ratios.

E. Follow manufacturer's instructions for mixing multi-component products.

3.03 INSTALLATION

A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.

1. Install backup material as recommended by sealant manufacturer.
2. Where possible, provide full length sections without splices; minimize number of splices.
3. Tape sealant may be used as joint filler if approved by sealant manufacturer.

B. Use bond breaker where recommended by sealant manufacturer.

C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.

D. Joint Sealant Materials: Follow manufacturer's recommendation and instructions, filling joint completely from back to top, without voids.

E. Joints: Tool slightly concave after sealant is installed.

1. When tooling white or light color sealant, use a water wet tool.
2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

F. Tape Sealant: Compress to 50 percent of expanded thickness and install in accordance with manufacturer's instructions.

3.04 CLEANING

A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.

B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

3.05 JOINT SEALANT SCHEDULE

A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project. When two or more sealant types are indicated, Contactor to submit desired selection.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Concrete Walls (except water-holding and belowgrade portions of structures)	1, 3, 4, 5, 6, 12
Concrete Floor Slabs (except for water-holding Structures)	2, 5
Concrete Walls and Slabs immersed in water and/or below grade	7
Slabs Subject to Vehicle and Pedestrian Traffic	2, 5
Masonry Walls	1, 3, 4, 5, 6, 7, 12, 13
Material Joints At:	
Metal Door and Louver Frames (Exterior)	1, 5, 6, 8, 12
Metal Door and Louver Frames (Interior)	1, 5, 6, 8, 9
Wall Penetrations (Exterior)	1, 5, 6, 8, 12
Wall Penetrations (Interior)	1, 5, 6, 8
Floor Penetrations	5, 6, 7
Ceiling Penetrations	1, 3, 4, 5, 6, 7
Roof Penetrations	5
Sheet Metal Flashings	5, 13 (Unless otherwise required by manufacturer)

Joint Locations	Sealant Type(s)
Sheet Metal Roofing and Siding	5, 13 (Unless otherwise required by manufacturer)
Other Joints:	
Threshold Sealant Bed	5

END OF SECTION

SECTION 08 11 00
METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A250.6, Hardware on Standard Steel Doors (Reinforcement - Application).
   b. A250.8, Recommended Specification for Standard Steel Doors and Frames.
   c. A250.11, Recommended Erection Instructions for Steel Frames.
2. ASTM International (ASTM):
   a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   b. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
3. Builders Hardware Manufacturers Association (BHMA): A156.115, Hardware Preparations in Standard Steel Doors and Frames.
4. Steel Door Institute (SDI): Specification for Standard Steel Doors and Frames (SDI-100).

1.02 SUBMITTALS

A. Action Submittals:

1. Applicable information for each type of door and frame, including:
   a. Frame conditions and complete anchorage details, supplemented by suitable schedules covering doors and frames.
   b. Relate to door numbers used in Contract Drawings.

B. Informational Submittals: Proposed Manufacturers Field Services per Section 01 43 33, Certificate of Compliance (or alternately, test results or calculations) that assure frames and anchorage design criteria meet requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.03 QUALITY ASSURANCE

A. Conform to requirements of ANSI A250.8 (SDI 100) and as supplemented by this section.

1.04 QUALIFICATIONS

A. Fabricator: Company specializing in performing the work of this section with minimum 5 years' documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Properly identify each item with number used in Contract Drawings.

B. Store doors upright, in protected dry area, at least 1 inch off ground or floor and at least 1/4 inch between individual pieces.

1.06 COORDINATION

A. Coordinate work in this section with door hardware sizes, types, and installation.

1.07 WARRANTY

A. Provide manufacturer's 5-year extended warranty in writing with Owner named as beneficiary. Warranty shall provide for correction or, at the option of the Owner, removal and replacement of steel doors and frames found defective during stated warranty period after the Date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Curries Manufacturing.
2. The Ceco Corp.
3. Mesker Industries, Inc.
4. Overly Manufacturing Co.
5. Pioneer Industries.
6. Steelcraft Manufacturing Co.
7. Stiles Custom Metal, Inc.

2.02 MATERIALS

A. Basic Metal Material: ASTM A1008/A1008M; sheet steel, cold-rolled, stretcher level.

B. Hollow Metal Frames:

1. Products of hollow metal door manufacturer.
2. ANSI 250.8, except as modified herein.
3. Frames for Doors: 14 gauge, with thermal break, for exterior, welded type, of cross-section shown.
4. Prepare floor and wall anchors, reinforcement, and cutouts for hardware to meet requirements of BHMA A156.115 and ANSI A250.6.
5. Finished size, shape, and profile of frame members as shown.
6. Concealed fasteners or welding are preferred to through-the-face fasteners.
7. Identification: Stamp opening number, as shown on Drawings, on center hinge reinforcement of each frame.

C. Hollow Metal Doors: ANSI A250.8, except as modified herein. BHMA A156.115 and ANSI A250.6 to receive hardware specified in Door and Hardware Schedule.

1. Exterior:
   a. Flush Panel Doors: 16 gauge, Level 3, Model 2.
   b. Flush end closure at top of doors.
   c. Polyurethane core.
   d. R-Value Minimum: 6.

2.03 MISCELLANEOUS ITEMS

A. Furnish manufacturer's standard core filler, anchors, fasteners, and other ancillary items unless noted otherwise.

B. Corrosion Coating for Grout Filled Frames:

1. Manufacturer Basis of Design: Steelcraft, frame back coating.

2.04 FACTORY FINISHING REQUIREMENTS

A. Galvanized with A60 zinc coating in accordance with ASTM A653/A653M (Wipe Coat galvanized coating is not acceptable).

B. Phosphate treat metal for paint adhesion.

C. One shop coat of baked-on rust-inhibiting prime coating compatible with finish coating as scheduled and as specified in Section 09 90 00, Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. Frames:

1. Follow ANSI A250.11 and manufacturer's instructions.
   a. Maintain scheduled dimensions, hold head level, and maintain jambs plumb and square.
   b. Secure anchorages and connections to adjacent construction.
   c. Wherever possible, leave frame spreader bars intact until frames are set perfectly square and plumb and anchors are securely attached.
2. Corrosion Coating: At jambs, pre-apply to back of frame surfaces prior to installation.
3. Insulate Frame Header: Fill header void with spray polyurethane foam as indicated in Section 07 21 00, Thermal Insulation.

B. Doors:

1. Hollow Metal Doors: ANSI A250.8.
2. Hardware: In accordance with manufacturer's templates and instructions.
   a. Adjust operable parts for correct function.
   b. Remove hardware, with exception of prime coated items, tag, box, and reinstall after finish paint work is completed.

3.02 FIELD PAINTING

A. Where prime coat has been damaged, sand smooth and touch up with same primer as applied at shop.

1. Remove rust before painting.
2. Touch Up: Not obvious.
3. Perform immediately after door and frame installation.

3.03 PROTECTION

A. Protect installed doors and frames against damage from other construction work.

3.04 SCHEDULES

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

SECTION 08 30 00
SPECIALTY DOORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. D3363, Standard Test Method for Film Hardness by Pencil Test.
   d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
2. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
3. National Fire Protection Association (NFPA): 70, National Electrical Code.
4. UL: Building Materials Directory.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data demonstrating compliance with specified requirements.
   b. Shop Drawings showing construction and installation details, including fastener type, and spacing required to meet design requirements, and electrical characteristics and control diagrams for motor operators.
   c. Identify each door with same reference as used on Drawings.
   d. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads specified and identified on the Structural Design Criteria on Drawings.
2. Samples:
   a. Manufacturer's current color sample(s) for factory finished coatings.
   b. Physical samples with proposed factory finish color for final color selection.

B. Informational Submittal: Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Structural Design Criteria on Drawings. Submit with Action Submittal for the same item.

1.03 QUALITY ASSURANCE

A. Qualifications: Experienced, factory authorized installer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors with separators and wrapping to protect units from damage during and after installation.

B. Store doors in protected dry area following manufacturer's requirements.

C. Handle doors according to manufacturer's instructions.

D. Protect exposed finish surfaces of prefinished items with wrapping.

PART 2 PRODUCTS

2.01 OVERHEAD COILING (ROLLUP) DOORS

A. Manufacturers and Products:

1. CornellCookson, Inc.; Thermiser Max ESD30.
2. Overhead Door Corp.; Stormtite 625.
3. Raynor Manufacturing Co.; DuraCoil.

B. Design Requirements:

1. Wind Loading: Complete assembly, each component and anchorage to building to withstand loads defined on General Structural Notes or a wind load of 30 pounds per square foot, whichever is greater.
2. Cycle Life: Design doors of standard construction for normal use of up to 20 cycles per day maximum, and an overall maximum of 50,000 operating cycles for the life of the door.
3. Insulated Door Slat Material Requirements: Flame Spread Index of 0 and a Smoke Developed Index of 10 as tested per ASTM E84.

C. Insulated Curtain: Interlocking insulated flat slats of 20-gauge (U.S. Standard) minimum steel with maximum R-value of 8 and backing to match face slat thermally separated from face slat.

D. Hood:

1. Match curtain material and finish.
2. Provide outdoor housing and components at exposed weather applications shown on Drawings.

E. Slide Guides: ASTM A36/A36M steel, shapes as appropriate for conditions.

F. Brackets, Gears, and Barrel: Manufacturer's standard items.

G. Operation:

1. Motor operated worm and gear to chain drive with pushbutton stations and endless chain or handcrank for emergency operation. Motor, UL listed and rated as 120/240 volt, single-phase, as required for Project.
2. Enclosures for Operator Controls and Stations: Provide NEMA 250, Type 4X, watertight and corrosion resistant enclosures for operator controls and stations.

H. Finish and Color:

1. Steel Curtain Slats, Guides, Hood, and Brackets: Hot-dip galvanize with G90 zinc coating in accordance with ASTM A653, phosphate treat for paint adhesion, and factory finish using a baked-on polyester powder coating. Coating hardness rated at H or better in accordance with ASTM D3363; minimum 2.5 mils cured film thickness. Color as scheduled in Door and Hardware Schedule on Drawings.
2. Other Steel Surfaces: One coat of corrosion-inhibiting prime paint compatible with finish paint specified in Section 09 90 00, Painting and Coating.

I. Special Features:

1. Bottom Bar:
   a. Provide extruded aluminum bottom bar with flexible weatherstripping astragal on exterior doors.
   b. Finish to match curtain slats.
   c. Provide limit switch and automatic stop and reversing feature in astragal.
2. End Locks and Wind Locks:
   a. Ends of each slat shall have end locks of material compatible with curtain.
   b. Provide wind locks at ends of every other slat minimum on exterior doors.

3. Weather Seals:
   a. Provide rubber, neoprene, or vinyl water seal at hood to prevent airflow around coil on exterior doors.
   b. Provide weather seal sealing strip on guide to close space between guide and curtain on exterior doors.

2.02 ACCESS DOORS

A. Manufacturers:

1. J.R. Smith, Montgomery, AL.
2. J.L. Industries, Bloomington, MN.
3. Milcor Inc., Lima, OH.

B. Manufactured Unit: Access door and frame with anchors to suit ceiling and wall conditions.

1. Basis of Design:
   a. J.R. Smith; XTS - Super Insulated Exterior Access Panel.
   b. Flush access panel with 2-inch polyisocyanurate, R-13 insulation.

C. Size: As shown on Drawings.

D. Door and Frame:

1. 20-gauge minimum stainless-steel door with one-piece 16-gauge stainless steel frame with 3/4-inch minimum exposed flange to cover edge of wall finish.

E. Hinges: Continuous hinge permitting a minimum of 160-degree door travel.

F. Locks: Standard locking black latch F4.

G. Finish: Type 304 stainless, No. 4 finish.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install special doors in accordance with the manufacturer's recommendations and printed instructions.

B. Provide pushbutton operators inside doors.

C. Adjust doors for smooth, satisfactory operation.

3.02 ACCESS DOOR INSTALLATION

A. Install access panel where shown on Drawings.

3.03 PRIME COAT TOUCHUP

A. Damaged Prime Coat:

1. Remove rust.
2. Sand smooth.
3. Use same primer as shop.
4. Touch up so it is not obvious.

3.04 PROTECTION

A. Protect installed doors against damage from other construction work.

3.05 SCHEDULE

A. For tabulation of overhead coiling door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Builders Hardware Manufacturer's Association (BHMA):
   a. A156.1, Butts and Hinges.
   b. A156.4, Door Controls - Closers.
   c. A156.13, Mortise Locks & Latches.
   d. A156.16, Auxiliary Hardware.
   e. A156.18, Materials and Finishes.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Manufacturer's literature for each item of finish hardware required herein, clearly marked.
   b. Finish Hardware Schedule: Furnish complete and detailed schedule, show product items, numbers, and finishes for hardware for each separate opening.
   c. Special Tools: Provide listing and description of usage.

B. Informational Submittals:

1. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
2. Manufacturer's Field Service Report.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, clearly identify and tag each item of hardware with respect to specified description and location of installation.

B. Provide secure storage for finish hardware until installation is made.

1.04 EXTRA MATERIALS

A. Special Tools: Two sets for installation and maintenance of hardware.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide end products of one manufacturer for each product in order to achieve standardization for appearance, maintenance, and replacement.

B. Finishes: BHMA A156.18.

2.02 FASTENERS

A. Stainless steel.

2.03 BUTT HINGES

A. BHMA A156.1.

B. Quantity per Door Leaf (Minimum):

Door Height	Hinges
5'-1" to 7'-7"	1-1/2 pair
7'-8" to 10'-0"	2 pairs

C. Hinge Height (Minimum):

Door Width	Hinge Height
Up to 3'-0"	4-1/2"
3'-1" to 4'-0"	5"

D. Width: Minimum for clearance of trim and 180-degree swing.

E. Exterior Hinges: Nonremoveable pin.

F. Joint Tolerance: 0.012 inch maximum, gauged in CLOSED position.

G. Finish: Satin stainless-steel No. 630.

H. Types and Manufacturers:

No.	Type Description	Stanley	Mc-Kinney	Lawrence	BHMA
H1	Regular weight, two ball-races, full mortise, stainless steel	FBB191-32D	TB2314	BB4101-32D	A5112

2.04 LOCKS AND LATCH SETS

A. Mortise Locks: BHMA A156.13, Series 1000, Grade 1.

1. Materials: Brass or stainless steel.
2. Trim: Wrought or forged lever handles and roses.
3. Core Cylinders: Interchangeable, removable; minimum of six pins.
4. Bolt Throw: 5/8 inch minimum.
5. Lever Backset: 2-3/4 inches.
6. Manufacturers and Products:
   a. Sargent; LNJ.
   b. Schlage; 03.
   c. Best; 3H Fairbanks.

B. Tactile Warning: Knurl lever handles for touch identification.

C. Finish: Satin stainless-steel No. 630 or satin chromium-plated No. 626.

D. Types and Manufacturers:

No.	Type Description	Best	Sargent	Schlage	BHMA
L1	Mortise entrance lock with lever handle	45H7TA3H	8245-LNJ	L9456P-03	F12, F13

E. Keying:

1. Lock Cylinders: Operate by grand master key system that allows for future expansion.
2. Keylocks: As directed by Owner.
3. Keys: Two per lock; tag with schedule information.
4. Master Keys: Four; send by registered mail to Owner.
5. Furnish lock manufacturer's removable core maximum security keying system.

2.05 CONSTRUCTION KEY SYSTEM

A. Removable construction core system for locks.

B. See Article Manufacturer's Services.

2.06 CLOSERS

A. BHMA A156.4.

B. Size closers in accordance with manufacturer's standards. Mount parallel arm closers on push side of doors.

C. Finish: Manufacturer's standard painted or powder coated finish, with special rust inhibiting (SRI) pretreatment, in color selected by Engineer from manufacturer's standard color range.

D. Types and Manufacturers:

No.	Type/Description	LCN	Sargent	BHMA
C6	Parallel arm with integral stop and hold-open	4110H Cush-N-Stop Series	351-PSH Series	C02061

2.07 KICKPLATES

A. Solid metal not plated. Bevel four edges.

B. Width of door leaf less than 1-1/2 inches at single leaf and less than 1 inch at pairs.

C. Finish: Satin stainless steel, No. 630.

D. Types and Manufacturers:

1. Ives or Rockwood as follows:
   a. K2: 36 inches high by 0.125 inch thick.

2.08 THRESHOLDS

A. Thresholds: One-piece full width of opening; extend beyond jamb where indicated.

B. Provide with stainless steel machine screws in threaded expansion anchors at concrete.

C. Finish: Mill finish aluminum, unless indicated otherwise.

D. Types and Manufacturers:

No.	Type Description	Pemko	Reese
T1	Saddle (smooth, 4" x 1/2")	175A	S104A

2.09 WEATHERSTRIP

A. Finish: Clear anodized aluminum, unless indicated otherwise.

B. Seal Types and Manufacturers:

No.	Type Description	Pemko	Reese
W1	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door shoe	222AV	DB596AF
	Rain drip	346C	R201C

2.10 TEMPLATES

A. Fabricate to template hardware applied to metal doors and frames.

B. Ensure that required templates are furnished to various manufacturers for fabrication purposes.

C. Templates: Make available not more than 10 days after receipt of approved Hardware Schedule.

2.11 EXIT DOORS

A. Exit Doors: Always openable from inside by simple turn of lever handle without use of key or any special knowledge or effort, to include each leaf of door pairs.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Make Work neat and secure, develop full strength of components, and provide proper function.

C. Prevent marring, scratching, or otherwise damaging adjacent finishes during hardware installation.

D. Latchbolts:

1. Install to engage in strikes automatically, whether activated by closers or manually.
2. In no case shall additional manual pressure be required to engage latchbolt in strike.

E. Wall Mounted Hardware: Install over solid structural backing or solid blocking in hollow walls.

F. Thresholds:

1. Cope ends neatly to profile of jamb.
2. Set in sealant and seal ends to jambs.

G. Hardware: Adjust for easy, noise-free operation.

H. Replace damaged hardware items.

3.02 MOUNTING DIMENSIONS

A. Standard Door Hardware Locations: As recommended and published by Door and Hardware Institute, except as noted or detailed otherwise.

3.03 MANUFACTURER'S SERVICES

A. Deliver permanent lock cores to Site.

B. Remove temporary construction cores and insert permanent cores.

C. Inspect each lock set to ensure permanent cores are operating satisfactorily.

D. Deliver to Owner change and control keys for permanent system.

E. Return temporary construction cores to manufacturer.

F. Furnish manufacturer's representative for the following services at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, inspection, and Manufacturer's Certificate of Proper Installation.
2. 1/2 person-day for functional and performance testing.

3.04 PROTECTION

A. Cover and protect exposed surfaces of hardware during installation and until Substantial Completion.

B. Fit, dismantle, and reinstall finish hardware as required for finish painting work.

C. Protect and prevent staining of hardware during construction in accordance with manufacturer's recommendations.

D. Remove protective measures and permanent lock cylinders installed prior to final cleaning.

3.05 DOOR AND HARDWARE SCHEDULE

A. Door and Hardware Schedule on Drawings is guide to functional requirements of each opening.

B. Provide finish hardware as scheduled. Sizes omitted shall be as recommended by manufacturer.

3.06 HARDWARE SETS

HDW-1:	Item	Type
	Butt Hinges (quantity as required for door height)	H1
	1 Lock	L1
	1 Closer	C6
	2 Kickplates (one each side)	K2
	1 Threshold	T1
	1 Set weatherstrip	W1
HDW-2:	All hardware by door manufacturer	

END OF SECTION

SECTION 08 90 00
LOUVERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500-L, Laboratory Methods of Testing Louvers for Rating.
2. American Architectural Manufacturers Association (AAMA): 2605, Voluntary Specification, Performance Requirements and Test Procedures, for Superior Performance Organic Coatings on Aluminum Extrusions and Panels.
3. ASTM International (ASTM): D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.

1.02 DESIGN REQUIREMENTS

A. Installed Louvers: Capable of withstanding loads defined on General Structural Notes or a wind load of 40 pounds per square foot, whichever is greater.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Large scale details of louvers, anchorage to structure including proposed fasteners and spacing, and relationship to adjoining construction. Demonstrate compliance with specified performance requirements.
   b. Schedule: Furnish complete and detailed schedule, show product items, numbers, and finishes for each separate louver opening.
2. Manufacturer's Literature: Descriptive and performance data of louvers, including standard drawings and louver-free area demonstrating compliance with the specified performance requirements.
3. Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
4. Samples: Manufacturer's standard finishes and colors.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Factory test data.
3. Certificates of AMCA ratings.
4. Installation instructions.
5. Parts list, if applicable.
6. Maintenance procedures.
7. Special Guarantee.

1.04 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction, or at option of Owner, removal and replacement of special fluorocarbon finish found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. Nonacoustical louver sizes are based on 50 percent free area and 800 fpm maximum velocity through free area unless indicated otherwise on Drawings.

B. Water Penetration Rate: No greater than 0.02 ounce per square foot.

C. Louvers: Rated and tested in accordance with AMCA 500-L.

D. Furnish louvers with interior duct collars.

2.02 DRAINABLE COMBINATION LOUVER/DAMPER (TYPE LD)

A. Frame: Extruded aluminum channel, 0.081 inch thick, 6 inches deep.

B. Blades: Extruded aluminum, minimum 0.081 inch thick, outside fixed, inside operating blades resting in normally closed position.

C. Pressure Loss: AMCA certified rating of no greater than 0.10-inch WC.

D. Sizes: Scheduled on Drawings.

E. Bird Screen: Inside mounted, painted aluminum, 1/2-inch mesh.

F. Finish: Kynar 500 fluorocarbon coating in color as scheduled or selected.

G. Manufacturer and Product: Ruskin ELC6375DAX.

2.03 ACCESSORIES

A. Anchors and Fasteners: Stainless steel.

B. Flashings: Match louver frame.

C. Isolation Tape: Tremco 440, 3M EC1202, or Presstite 579.6.

D. Isolation Paint: ASTM D1187, bituminous coating.

2.04 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. Airflow versus pressure loss.
2. Rain penetration data.

PART 3 EXECUTION

3.01 EXAMINATION

A. Check openings to ensure dimensions conform to Drawings.

B. Ensure openings are free of irregularities that would interfere with installation.

C. Do not install louvers until defects have been corrected.

3.02 INSTALLATION

A. Install louvers as shown on reviewed Shop Drawings. Coordinate with heating or ventilation ductwork to be connected.

B. Follow procedures in manufacturer's recommended installation instructions.

C. Separate aluminum from other metals with isolation tape or paint.

3.03 ADJUSTING AND CLEANING

A. Set adjustable louver blades for uniform alignment in OPEN and CLOSED positions.

B. Adjust louvers so moving parts operate smoothly.

C. After erection, protect exposed portions from damage by machines, paint, lime, acid, cement, or other harmful compounds.

D. Remove protective materials and clean with plain water, water with soap, or household detergents.

3.04 SCHEDULE

A. For tabulation of louver characteristics, such as size, type, detail, and finish requirements, see Louver Schedule on Architectural Drawings.

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): F3125/F3125M, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.
2. American Water Works Association (AWWA):
    a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
    b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
    c. C210, Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
    d. C213, Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
    e. C214, Tape Coatings for Steel Water Pipelines.
3. Environmental Protection Agency (EPA).
4. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
5. National Association of Pipe Fabricators (NAPF): NAPF 500-03, Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
    a. 500-03-01: Solvent Cleaning.
    b. 500-03-02: Hand Tool Cleaning.
    c. 500-03-03: Power Tool Cleaning.
    d. 500-03-04: Abrasive Blast Cleaning for Ductile Iron Pipe.
    e. 500-03-05: Abrasive Blast Cleaning for Cast Ductile Iron Fittings.
6. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
7. Occupational Safety and Health Act (OSHA).
8. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.

9. The Society for Protective Coatings (SSPC):
    a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
    b. PA Guide 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
    c. SP 1, Solvent Cleaning.
    d. SP 2, Hand Tool Cleaning.
    e. SP 3, Power Tool Cleaning.
    f. SP 5, White Metal Blast Cleaning.
    g. SP 6, Commercial Blast Cleaning.
    h. SP 7, Brush-Off Blast Cleaning.
    i. SP 10, Near-White Metal Blast Cleaning.
    j. SP 11, Power Tool Cleaning to Bare Metal.
    k. SP 13, Surface Preparation of Concrete.
    l. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
    m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PPDS: Paint Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Data Sheets:
        1) For each product, furnish a Paint Product Data Sheet (PPDS), manufacturer's technical data sheets, and paint colors available (where applicable). PPDS form is appended to end of this section.

2) For each paint system, furnish a Paint System Data Sheet (PSDS). PSDS form is appended to end of this section.
3) Technical and performance information that demonstrates compliance with specification.
4) Furnish copies of paint system submittals to the coating applicator.
5) Indiscriminate submittal of only manufacturer's literature is not acceptable.

b. Detailed chemical and gradation analysis for each proposed abrasive material.

2. Where ANSI/NSF Standard 61 approval is required, submit ANSI/NSF certification letter for each coating in the system indicating product application limits on size of tank or piping, dry film thickness, number of coats, specific product tested, colors certified, and approved additives.
3. Provide TCLP test data for lead and other regulated heavy metals in nonrecyclable, slag type abrasive blast media to be used on the Project. Acceptable abrasive test data shall indicate the abrasive manufacturer, location of manufacture, and media gradation and type. Surface preparation will not be permitted to begin until acceptable test data has been submitted.
4. Samples:
   a. Proposed Abrasive Materials: Nominal 2-pound sample for each type.
   b. Reference Panel:
      1) Surface Preparation:
         a) Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
         b) Provide panel representative of the steel used; prevent deterioration of surface quality.
         c) Panel to be reference source for inspection upon approval by Engineer.
      2) Paint:
         a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.
         b) Furnish additional samples as required until colors, finishes, and textures are approved.
         c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. Coating for Faying Surfaces: Manufacturer's test results that show the proposed coating meets the slip resistance requirements of the AISC Specification for Structural Joints using ASTM F3125/F3125M bolts.
6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
7. Manufacturer's written instructions and special details for applying each type of paint.
8. If manufacturer of finish coating differs from that of shop primer, provide written confirmation from both manufacturers that materials are compatible.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

B. Regulatory Requirements:

1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
2. Perform surface preparation painting, and waste collection and disposal in accordance federal, state, and local agencies having jurisdiction.

C. Perform surface preparation and painting in accordance with these specifications, paint manufacturer's written instructions, and SSPC PA Guide 10.

D. Mockup:

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Deliver paint to the Site in unopened containers that plainly show, at time of use, designated name, date of manufacture, color and name of manufacturer.
2. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
3. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

B. Status of Existing Coatings: Protect existing coatings where work is not being performed. Damage that has occurred to existing coating systems consult project Engineer to determine course of action.

1.07 WARRANTY

A. The Contractor shall warrant to the Owner and guarantee the Work under this section against defective workmanship and materials for a period of 1 year commencing on the date of final acceptance of the Work.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. Ameron Protective Coatings, Brea, CA.
2. Carboline Coatings Company, St. Louis, MO.
3. ICI Devoe Coatings Company, Louisville, KY.
4. Dupont Chemical Co., Wilmington, DE.
5. Kop-Coat, Inc., Pittsburgh, PA.
6. International Coatings, Louisville, KY.
7. Sherwin Williams, Cleveland, OH.
8. Tnemec Coatings, Kansas City, MO.
9. Wasser Coatings, Seattle, WA.

2.02 ABRASIVE MATERIALS

A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.03 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition
Acrylic Latex	Single-component, finish as required
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil
Bituminous Paint	Single-component, coal-tar pitch based
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
Elastomeric Polyurethane	100% solids, plural component, spray applied, high build, elastomeric polyurethane coating, suitable for the intended service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Inorganic Zinc Primer	Solvent or water based, having 85% metallic zinc content in the dry film; follow manufacturer's recommendation for topcoating
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
Organic Zinc Rich Primer	Epoxy or moisture cured urethane with 85-percent zinc content in the dry film, meeting the requirements of RCSC Specification for Structural Joints using High Strength Bolts, Class A or Class B, as required.

Product	Definition
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading
Silicone/Silicone Acrylic	Elevated temperature silicone or silicone/acrylic based
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Provide ductile iron pipe to be painted without asphalt coating.
   b. Grind smooth surface imperfections, including delaminating metal and annealing oxide, that is not tightly adhered.
   c. Remove oil, grease, and other surface contaminants in accordance with NAPF 500-03-01, Solvent Cleaning.
   d. Abrasive blast clean in accordance with the following:
      1) Ductile Iron Pipe: NAPF 500-03-04.
      2) Cast Ductile Iron Fittings: NAPF 500-03-05.
   e. Exposed surfaces of metal at small coating defects may be prepared by Hand Tool Cleaning NAPF 500-03-02 or Power Tool Cleaning NAPF 500-03-03. Small coating defects are defined as a defect that exposes 2 square inches or less of bare metal.
2. Steel Pipe:
   a. Surface preparation and application of primer and shop applied finish coats shall be performed by pipe manufacturer.
   b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

C. Test shop applied primer for compatibility with subsequent cover materials.

D. Measure moisture content of surfaces using electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following maximums or the maximum recommended by the manufacturer, whichever is more stringent:

1. Gypsum Wallboard: 12 percent.
2. Concrete: 12 percent.
3. Concrete Floors: 8 percent.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

B. Surface Contamination Testing:

1. A surface contamination analysis test shall be performed every 500 square feet by means of a Chlor Test CSN Salts or approved equivalent.
2. Surface with chloride levels exceeding 3 µg/square centimeter for submerged surfaces and 5 µg/square centimeter for exposed surfaces shall be treated with a liquid soluble salt remover equivalent to CHLOR*RID (CHLOR*RID International, Chandler, AZ).
   a. Test decontamination water for chloride content prior to use.
   b. Chloride Limit: 100 mg/L.
   c. Locally available potable water meeting chloride limit is acceptable for decontamination. If locally available potable water exceeds chloride limit, provide imported water that meets specified chloride limit.
3. Follow manufacturer's recommendations and procedures for the use of this product to remove the surface contamination.

C. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
   a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
   b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
   c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
   d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
   e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
   f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.

g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

i. SP-16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Hand tool clean areas that cannot be cleaned by power tool cleaning.
5. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
6. Welds and Adjacent Areas:
   a. Prepare such that there is:
      1) No undercutting or reverse ridges on weld bead.
      2) No weld spatter on or adjacent to weld or any area to be painted.
      3) No sharp peaks or ridges along weld bead.
   b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
7. Preblast Cleaning Requirements:
   a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.

b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
c. Clean small isolated areas as above or solvent clean with suitable solvent and clean cloth.

8. Blast Cleaning Requirements:
   a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
   b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
   c. Use only dry blast cleaning methods.
   d. Do not reuse abrasive, except for designed recyclable systems.
   e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
9. Post-Blast Cleaning and Other Cleaning Requirements:
   a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
   b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

D. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Brush blast in accordance with SSPC SP 16.
2. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

E. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.

5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

F. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

G. Masonry Surface Preparation:

1. Complete and cure masonry construction for 14 days or more before starting surface preparation work.
2. Remove oil, grease, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable cleaning methods.
3. Clean masonry surfaces of mortar and grout spillage and other surface deposits using one of the following:
   a. Nonmetallic fiber brushes and commercial muriatic acid followed by rinsing with clean water.
   b. Brush-off blasting.
   c. Water blasting.
4. Do not damage masonry mortar joints or adjacent surfaces.
5. Leave surfaces clean and, unless otherwise required for proper adhesion, dry prior to painting.
6. Masonry Surfaces to be Painted: Uniform texture and free of surface imperfections that would impair intended finished appearance.
7. Masonry Surfaces to be Clear Coated: Free of discolorations and uniform in texture after cleaning.

H. Wood Surface Preparation:

1. Replace damaged wood surfaces or repair in a manner acceptable to Engineer prior to start of surface preparation.
2. Solvent clean (mineral spirits) knots and other resinous areas and coat with shellac or other knot sealer, prior to painting. Remove pitch by scraping and wipe clean with mineral spirits or turpentine prior to applying knot sealer.
3. Round sharp edges by light sanding prior to priming.

4. Filler:
    a. Synthetic-based wood putty approved by paint manufacturer for paint system.
    b. For natural finishes, color of wood putty shall match color of finished wood.
    c. Fill holes, cracks, and other surface irregularities flush with surrounding surface and sand smooth.
    d. Apply putty before or after prime coat, depending on compatibility and putty manufacturer's recommendations.
    e. Use cellulose type putty for stained wood surfaces.
5. Ensure surfaces are clean and dry prior to painting.

I. Gypsum Board Surface Preparation: Typically, new gypsum board surfaces need no special preparation before painting.

1. Surface Finish: Dry, free of dust, dirt, powdery residue, grease, oil, or any other contaminants.

J. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.
7. Application of Cosmetic Coat:
    a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
    b. Check compatibility by application to a small area prior to starting painting.
    c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.

3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
   a. Rate: Approximately 2 gallons per 100 square feet.
   b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
   c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
   d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
   e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
   f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for existing and new, interior and exterior wood, masonry, concrete, and metal, and submerged metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Do not paint exterior concrete surfaces, unless specifically indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers' printed recommendations and special details. In the event of conflicting requirements, the most stringent shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Sand wood lightly between coats to achieve required finish.
6. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
7. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
8. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
9. Water-Resistant Gypsum Board: Use only solvent type paints and coatings.
10. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
11. Keep paint materials sealed when not in use.
12. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such As Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
    a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
    a. Minimum required without regard to coating thickness.
    b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
    a. Do not exceed coating manufacturer's recommendations.
    b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
    a. Perform with properly calibrated instruments.
    b. Recoat and repair as necessary for compliance with specification.
    c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. System No. 1 Submerged Metal—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	NSF Epoxy	3 coats, 3 MDFTPC

1. Use on the following items or areas:
   a. Metal surfaces new and existing below a plane 1 foot above the maximum liquid surface; metal surfaces above the maximum liquid surface that are a part of the immersed equipment.
   b. Surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel that are embedded in concrete.
   c. Interior surfaces of steel piping where specifically required to be epoxy-lined.
   d. Buried or concrete encase metal surfaces which are not coated with System No. 8.
   e. Exterior coating of steel pipe located in vaults and where epoxy coating is specifically required. Final field coating of steel pipe in vaults shall include System No. 4 Top Coat of Wasser Ferrox A and B.
   f. As indicated on Drawings.

C. System No. 2 Submerged Metal – Coal Tar or High Build Epoxy:

Surface Prep.	Paint Material	Min. Coats, Cover
Shop Applied: SP 5, White Metal Blast Cleaning	MC Zinc 100 Primer	1 Coat, 5.0 MDFT
Field Applied: Solvent Clean (SP 1) Followed Power Tool (SP 3)	Coal-Tar Epoxy MC-Tar 100	2 coats, 5.0 MDFTPC
	-OR-	
	High Build Epoxy	2 coats, 5.0 MDFTPC

1. Use on the following items or areas:

   a. All field repairs and field joints for interior linings of epoxy-lined raw water steel pipelines shall use the Wasser MC Zinc/MC Tar system listed above. Potable water steel pipelines shall use an NSF 61 approved high build epoxy.
   b. Use on exterior field coating of steel pipe where specifically required to be epoxy coated.
   c. As indicated on Drawings.

D. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
Shop Application: Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Potable Grade, Polyamide Epoxy Coating (Shop Applied)	3 coats, 12 MDFT
Field Application: Solvent Clean (SP-1) followed by Hand Tool or Power Tool Cleaning to roughen surface (SP-2 or SP-3)	Wasser Ferrox B (Field Applied)	1 coat, 3.5 MDFT
	Wasser Ferrox A (Field Applied)	1 coats, 3.5 MDFT

1. Use on the following items or areas:
   a. All new and existing exposed metal surfaces located inside of structures, vaults, manholes, and other below grade locations, or other surfaces that may be subject to high humidity or condensation.
   b. As indicated on Drawings.
2. Shop apply potable grade polyamide epoxy Coating per System No. 1. Following installation at the Project Site surface prepare items to be coated per Specifications and coating manufactures recommendation and then field apply Wasser Ferrox B and A.

E. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing located inside or outside of structures and exposed to weather.
   b. As indicated on Drawings.

F. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Polyurethane	1 coats, 35 MDFT

1. Use on the following items or areas:
   a. Buried or concrete encased ferrous metal, excluding steel pipe which shall be coated in accordance with Section 09 90 10, Pipeline Coating and Lining.
   b. Minor appurtenance pipe, and fittings, and appurtenances shall be coated with this system, unless otherwise specified.
   c. Epoxy coating in accordance with System No. 1 shall be allowable only when approved by the Engineer. Manufacturer shall specifically request the use of System No. 1 in writing for Engineer review and approval.

G. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1) Followed by Hand Tool (SP 2) or Power Tool (SP 3)	Wash Primer	1 Coat, 0.4 MDFT
	Finish Coats as specified for exposure or location	Per the specified system

1. Use on the following items or areas:
   a. All immersed and buried galvanized surfaces. All wall pipe sleeves, pipe supports and other minor appurtenances unless noted otherwise.
      1) As indicated on Drawings.

H. System No. 11 Organic Zinc Rich Primer:

Surface Prep.	Paint Material	Min. Coats, Cover
Type 11a: SP 10, Near-White Blast Cleaning Type 11b: Solvent Clean (SP 1) Followed by Hand Tool (SP 2), or Power Tool (SP 3), or Brush-off Blast (SP 7)	Organic Zinc Rich Primer	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. System 11a: Faying surfaces of slip critical joints as specified and as shown on Drawings.
   b. System 11b: Galvanized surfaces chipped, abraded, or otherwise damaged.
2. For use in connection with faying surfaces of slip critical joints, provide primer in accordance with RCSC Specification for Structural Joints using High-Strength Bolts.

I. System No. 12 Skid-Resistant—Steel:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT

1. Use on the following items or areas:
   a. As indicated on Drawings.

J. System No. 13 Skid-Resistant—Aluminum and FRP:

Surface Prep.	Paint Material	Min. Coats, Cover
Aluminum: In accordance with Article Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation -OR- FRP: In accordance with Paragraph Plastic and FRP Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT

1. Use on the following items or areas:
   a. As indicated on Drawings.

K. System No. 14 High Heat-Resistant—700 Degrees F Maximum:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Inorganic Zinc Primer	1 coat, 2.5 MDFT
	Silicone	1 coat, 2 MDFT

1. Use on the following items or areas:
   a. As indicated on Drawings.

L. System No. 15 Heat-Resistant—425 Degrees F Maximum:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Inorganic Zinc Primer	1 coat, 2.5 MDFT
	Silicone Acrylic (limited colors)	2 coats, 2 MDFT

1. Use on the following items or areas:
   a. As indicated on Drawings.

M. System No. 18 Concrete Exposed Metal Repair Coating—Potable Water and Non-Submerged:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1	NSF Epoxy; finish color white	2 coats, 4 MDFTPC, see Note 2.
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. Use this system:
   a. On saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum 2 inches around ends of exposed metal and rebar in lieu of entire surface.

N. System No. 21 Skid-Resistant—Concrete:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:
   a. As indicated on Drawings.

O. System No. 22 Chemical-Resistant Wall, Heavy-Duty—Concrete or Masonry:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete or Paragraph Masonry Surface Preparation	Epoxy Filler/Surfacer	1 coat as required to fill voids and smooth surface; apply to 100 percent of surface.
	High Build Epoxy	1 coat, 160 SFPG
	High Build Epoxy, Gloss	1 coat, 160 SFPG

1. Use on the following items or areas:
   a. As indicated on Drawings.

P. System No. 23 Chemical-Resistant Wall—Concrete and Masonry:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete or Paragraph Masonry Surface Preparation	Epoxy Filler/Surfacer	1 coat , as required to fill voids and smooth surface; apply to 100 percent of surface.
	High Build Epoxy	1 coat, 160 SFPG

1. Use on the following items or areas:
   a. As indicated on Drawings.

Q. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex (Semigloss)	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.
   b. As indicated on Drawings.

R. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on the following items or areas:
   a. Between contact surfaces of dissimilar metals.
   b. On aluminum surfaces embedded or in contact with concrete.
   c. As indicated on Drawings or otherwise specified.

S. System No. 29 Fusion Bonded Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating	1 or 2 coats, 7 MDFT

1. For steel pipe and fittings, meet all requirements of AWWA C213.
2. Use on the following items:
   a. Use on individual pipe couplings, fittings, and valves where specifically indicated and required in the individual pipe and equipment specifications.
   b. As indicated on Drawings.

3.08 COLORS

A. Provide as shown in Architectural Schedules on Drawings, shown for equipment and appurtenances and designated herein, and shown in Piping Schedule.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected.
3. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.

c. Radiation Hazards: OSHA Purple.
d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: As shown in table below.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.
4. Pipe Supports: Painted light gray, as approved by Owner.
5. Fiberglass reinforced plastic (FRP) pipe, polyvinylidene fluoride (PVDF), and polyvinyl chloride (PVC) pipe located inside of buildings and enclosed structures will not require painting, except as noted or scheduled.

E. Pipe System Color Code:

Pipe System	Color
Air, Process	Federal Safety Green
Air, Instrument	Federal Safety Purple
Compressed Air	Federal Safety Purple
Dewatering	Black
Drains	Black
Filter Backwash Supply	Medium Blue
Overflow	Silver/Gray
Potable Water	Light Blue
Sample	Medium Green

3.09 FIELD QUALITY CONTROL

A. Inspection:

1. Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by

Engineer. Provide additional staging and lighting as requested by Engineer.

2. Inspection shall include printed directions and recommendations of paint manufacturer.
3. Provide Engineer minimum 7 days' advance notice prior to start of surface preparation work or coating application work.
4. Perform work only in the presence of Engineer, unless Engineer grants prior approval to perform such work in Engineer's absence. Approval to perform work in the Engineer's absence is limited to the current day unless specifically noted to extend beyond the completion of the workday.
5. Inspection by the Engineer, or the waiver of inspection of any particular portion of the work, shall not be construed to relieve the Contractor of responsibility to perform the Work in accordance with these Specifications.

B. Thickness Testing:

1. Measure dry film coating thickness in mils with an electronic or magnetic type, dry film thickness gauge, in accordance with SSPC PA 2.
2. Acceptable gauges available from Defelsko, Nordson, "or-equal".
3. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.

C. Holiday Testing:

1. Thin Film Coatings:
   a. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   b. Equipment: Tinker and Rasor Model M-1, TQC Low Voltage Pinhole Detector, "or-equal".
2. Thick Film Coatings:
   a. Holiday detect coatings 20 mils thick or more with high voltage electrical holiday detector in accordance with NACE SP0188.
   b. Equipment: As recommended by coating manufacturer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.

3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand sand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

F. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

3.10 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. Minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.11 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

D. Collect, store, and dispose of waste in accordance with applicable federal, state, and local regulations.

3.12 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this specification:

1. Paint System Data Sheet (PSDS).
2. Paint Product Data Sheet (PPDS).

END OF SECTION

PAINT SYSTEM DATA SHEET (PSDS)

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	Product Name/Number (Proprietary)	Min. Coats, Coverage

PAINT PRODUCT DATA SHEET (PPDS)

Complete and attach manufacturer's Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning:_____

Ambient Temperature Limitations: min.:_____ max.:_____

Surface Temperature Limitations: min.:_____ max.:_____

Surface Profile Requirements: min.: _____ max.:_____

Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.

SECTION 09 90 10
PIPELINE COATING AND LINING

PART 1 GENERAL

1.01 GENERAL

A. This section covers the Work necessary to apply an external tape wrap on steel pipe, field coating of joints, and field repair of coating damage, complete.

B. Steel pipe shall have a tape wrap coating system with cement mortar overcoat, unless specifically indicated otherwise.

C. Pipeline lining shall be mortar lined, except where required to be epoxy lined areas as shown on Drawings or indicated otherwise.

D. Exposed steel pipe shall be coated as specified in Section 09 90 00, Painting and Coating, unless specifically indicated otherwise.

1.02 REFERENCES

A. General: The latest revision of the following minimum standards shall apply to the coating and lining materials, testing, and installation except where standards that are more stringent are applicable.

1. American Water Works Association (AWWA):
   a. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe – 4-inch and Larger - Shop Applied.
   b. C209, Cold-Applied Tape Coating Systems for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
   d. C216, Heat-shrinkable Cross-linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
2. National Association of Corrosion Engineers (NACE): Recommended Practice RP-274, High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.
3. Steel Structures Painting Council (SSPC):
   a. SP-1, Solvent Cleaning Surface Preparation.
   b. SP-2, Hand Tool Cleaning Surface Preparation.
   c. SP-3, Poor Tool Cleaning Surface Preparation.

d. SP-5, White Metal Abrasive Blast Surface Preparation.
e. SP-6, Commercial Abrasive Blast Surface Preparation.
f. SP-10, Near White Metal Abrasive Blast Surface Preparation.
g. SP-11, Power Tool to Bare Metal.

1.03 DEFINITIONS

A. Manufacturer's Representative: Employee of coating manufacturer who is factory trained and knowledgeable in all technical aspects of their products and systems. Sales representatives are not acceptable as a technical representative unless written authorization from the coating manufacturer is provided which states the sales representative has full authority to act on the behalf of the coating manufacturer.

1.04 ABBREVIATIONS

A. ANSI: American National Standards Institute.

B. AWWA: American Water Works Association.

C. MDFT: Minimum Dry Film Thickness.

D. Mil: Thousandths of an inch.

E. OSHA: Occupational Safety and Health Act.

F. SSPC: Steel Structures Painting Council.

1.05 SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00, Submittal Procedures.

B. Catalog cuts and other manufacturer's information shall be submitted for all materials provided.

C. Provide catalog cuts and other information for all products proposed for use that show compliance of those materials with these Specifications.

D. Provide copy of approved coating system submittals to the coating applicator.

E. Quality Control Submittals:

1. Furnish the following:
   a. Applicator's Experience: List of references substantiating this requirement as specified.
   b. Factory-Applied Coatings: Coating manufacturer's certification stating the applicator meets or exceeds their coating application requirements and recommendations.
   c. Coating manufacturer shall provide a copy of the manufacturer's coating application quality control manual.
   d. Coating applicator shall provide a monitoring system approved by the coating manufacturer that constantly records pipe and coating conditions during coating application. Recorded monitoring parameters shall include, but not be limited to, pipe temperature, line speed, surface preparation, holiday test, and other parameters applicable to the type of coating.
   e. If the manufacturer of field-applied coating differs from that of the shop-applied primer, provide written confirmation from both manufacturers' that the two coating materials are compatible.

1.06 QUALITY ASSURANCE

A. Coating Applicator's Experience and Certification:

1. Coating Applicator and the coating application personnel shall have a minimum of 5 years' practical experience in application of the specified coating system.
2. Coating applicator shall be certified by the coating manufacturer as an approved applicator.

B. Coating and/or lining manufacturer technical representative shall be present for a minimum of 3 days technical assistance and instruction at the start of coating and/or lining operations within the shop. During this visit, the technical representative shall observe surface preparation and coating application and conduct tests of the coating to ensure conformance with application instructions, recommended methods, and conditions.

C. Coating and/or lining manufacturers' technical representative shall be onsite for 3 working days, minimum, at the start of each construction season to inspect coating application and procedures in the field. During this visit, the technical representative shall observe surface preparation and coating application and conduct tests of the coating to ensure conformance with application instructions, recommended methods, and conditions.

D. Coating and/or lining manufacturer shall include 8 hours per month of field or shop coating technical support when requested by the Engineer.

E. Technical representative shall provide a written report to the Engineer for each visit. Report shall include copies of test data collected, description of observations, and all recommended corrective actions. Report shall be submitted within 5 working days after the visit. When deemed necessary by the Engineer, work will not be permitted to proceed until the recommended corrective actions have been implemented. After all corrective recommendations have been completed, the manufacturer representative shall return and certify that the application complies with the manufacturer's coating application recommendations.

F. Additional visits by the manufacturer's representative shall be made at sufficient intervals during surface preparation and coating or lining as may be required for product application quality assurance, and to determine compliance with manufacturer's instructions, and as may be necessary to resolve problems attributable to, or associated with, manufacturer's products furnished for this Project.

1.07 WARRANTY

A. The Contractor and coating applicator shall warrant to the Engineer and guarantee the Work under this section against defective workmanship and materials for a period of 5 years commencing on the date of final acceptance of the Work.

1.08 OBSERVATION OF WORK

A. The Contractor shall give the Engineer a minimum of 7 days advance notice of the start of any work to allow scheduling for shop or field observation.

B. Provisions shall be made to allow Engineer full access to facilities and appropriate documentation regarding coating application.

C. Observation by the Engineer or the waiver of observation of any particular portion of the Work shall not be construed to relieve the Contractor of Contractor's responsibility to perform the Work in accordance with these Specifications.

D. All materials shall be subject to observation for suitability as the Engineer may elect, prior to or during incorporation into the Work.

PART 2 PRODUCTS

2.01 GENERAL

A. Coatings and linings will be stored, handled, and applied per manufacturer's written directions.

B. Exterior and interior pipe and fitting surfaces shall be cleaned, primed, and coated in accordance with referenced standards, written directions of the coating or lining manufacturer's, and these Specifications, whichever is more stringent.

C. Pipeline coating or lining shall be the product of a single manufacturer. Product substitutions during the Project will not be permitted, without Engineer's approval.

2.02 EXTERIOR SHOP-APPLIED COATINGS

A. General:

1. Steel pipe shall be coated in accordance with AWWA C214 with a cement mortar overcoat, as modified herein, unless specifically specified otherwise.
2. Steel pipe specified to receive a cement mortar overcoat will be shop-coated with the required coating system and a 1-inch thick, minimum, cement mortar overcoat as specified herein.
3. Pipe that is atmospherically exposed shall be shop primed as specified herein and coated per Section 09 90 00, Painting and Coating.
4. Buried dielectrically coated pipe and fittings passing through a structure wall or floor shall be dielectrically coated for a minimum of 2 inches beyond the interior wall or floor surface. For dielectrically coated pipe that also includes a cement mortar coating, stop the cement mortar coating at 3 inches into the outside face of the structure wall of floor.

B. Coating Systems:

1. Polyethylene Tape Wrap:
   a. Pipe shall be coated with one of the following 80-mil (nominal), tape-coating systems applied in accordance with AWWA C214, except as modified herein.
      1) Polyken YGIII Tape Coating System:
         a) Primer: Polyken 1019, 1027, 1029, or as recommended by the coating manufacturer.
         b) Weld Stripe Tape: Polyken 931 (no backing), 25 mils nominal, 4 inches wide minimum.

c) Inner Wrap: Polyken 989 YGIII, 20 mils nominal, corrosion protection layer.
d) Middle Wrap: Polyken 955 YGIII, 30 mils nominal, mechanical protection layer.
e) Outer Wrap: Polyken 956 YGIII, 30 mils nominal, mechanical protection layer.
f) Shop coat fittings and specials with two-layer, 80-mil coating system Polyken YGIII 930-50/905-30 hand tapes, or manufacturer recommended equal. Two-layer white 100-mil coating system Polyken YGIII 932-50 is an equal system.

b. At pipe fabricator's option, provide weld stripe tape or grind welds as specified this section.
c. All new steel pipe specified to be tape wrapped shall be cleaned and prepared per SSPC-SP-10, Near White blast.
d. Tape layers shall have adhesive for the full width of the tape. Adhesive shall have the ability to stick to itself and to the proceeding tape layer or pipe.
e. Each layer shall be a different color or shade with the outer layer white.
f. Outer wrap shall have sufficient ultraviolet (UV) inhibitors to resist above grade exposure for a minimum of 12 months or the proposed storage and construction time, whichever is greater.
g. Tape width shall be 12 inches maximum. Wider tape will be conditionally allowed if the coating applicator can demonstrate that proper tensioning can be maintained and mechanical wrinkling prevented throughout the coating application. If at any time during the pipe fabrication tape quality becomes inconsistent with a wider tape, the Engineer can require the remainder of the pipe to be coated using the maximum specified tape width.

2. Exterior Coating for Exposed Steel Pipe:
   a. Exposed piping shall be shop primed with coating System No. 4 or System No. 5 as specified in Section 09 90 00, Painting and Coating.
   b. Manufacturer of shop-applied primer shall be coordinated with field application to provide a completed system by a single manufacturer as specified in Section 09 90 00, Painting and Coating. Engineer approval of a coating system with two or more coating manufacturers will require written approval from all coating manufacturers as to compatibility and acceptance under warranty.
3. Cement Mortar Over Coat:
   a. Apply cement mortar over coat over the tape wrap coating system on steel pipe in accordance with AWWA C205, except as modified herein.

b. Cement: Conform to ASTM C150, Type II.
c. Aggregate shall be silica sand or other aggregate that is not subject to leaching. Conform to ASTM C33.
d. Cement mortar mixture shall consist of 1 part cement to not more than 3 parts aggregate.
e. Water for Cement Mortar: Clean and free from organic matter, strong alkalis, vegetable matter, and other impurities. Use no more than 4-1/2 gallons of water per sack of cement.
f. Cement Mortar Coating: 1-inch thick minimum.

2.03 INTERIOR SHOP-APPLIED LININGS

A. Cement Mortar Lining: Cement mortar lining shall be in accordance with Section 33 05 01.01, Welded Steel Pipe and Fittings.

2.04 SPECIALS, FITTINGS, AND CONNECTIONS

A. Coating and lining application for special sections, connections, and fittings for steel pipe shall conform to the coating system and application requirements as specified in this section.

B. Specials, fittings, and connections shall be defined as any pipe section with turnouts for blowoffs, interconnections, or any valve or other appurtenances; tees; crosses; wyes; laterals; manholes; mitered angle or elbows; and pipes which require special fabrication that prevents mechanical production application of the specified coating system from end to end of pipe joint, except elbow fittings as defined herein.

C. Buried specials, fittings, and connections with hand applied tape or heat shrink sleeves shall also include a shop applied cement mortar “armor” overcoat.

D. Where steel pipe specials are to be concrete encased, steel pipe may be tape or epoxy coated.

2.05 EXTERIOR FIELD JOINT COATING

A. Welded pipe joints shall be field coated after pipe assembly in accordance with AWWA C216, except as modified herein.

B. Buried flanges and couplings shall be field coated with wax tape as specified in Section 33 05 01, Conveyance Piping–General.

C. Field joint coating shall be compatible with the shop-applied coating system and provided by the same manufacturer or a manufacturer approved by the pipe coating manufacturer.

D. All joints on pipe shall be coated with a heat shrink coating material. Field joints on mortar over coated pipe shall also be coated with cement mortar.

E. Field joint coating materials shall be as follows or an approved equal.

1. Heat Shrink Sleeves:
    a. Filler Mastic: Provide mastic filler for all push-on type joints. Size and type shall be as recommended by the sleeve manufacturer for type of pipe and joint.
    b. Joint Coating: Heat shrink, cross-linked polyolefin wrap or sleeve with a mastic sealant, 85 mils minimum thickness, suitable for pipeline operating temperature, as recommended by the manufacturer.
    c. Provide standard recovery sleeve for girth weld or bell and spigot steel pipe joints.
    d. Width of heat shrink sleeves shall be sufficient to overlap existing coating 2 inches minimum. Overlap on tape coated steel pipe shall be based on a sequential 2-inch wide step from outer wrap to middle wrap to inner wrap.
    e. Consideration sleeve shrinkage during installation and joint profile in determining sleeve width required. Overlapping of two or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without Engineer approval.
    f. Manufacturers:
        1) Canusa.
        2) Polyken (Raychem).
        3) “Or-equal.”
2. Cement Mortar Overcoat:
    a. Joints of cement mortar overcoated steel pipe shall be mortar coated as specified herein after application of the specified joint coating materials, where applicable.
    b. Polyethylene foam-lined fabric with steel strapping of sufficient strength to hold the fresh mortar, resist rodding of the mortar and allow excess water to escape.
        1) 100 percent closed-cell.
        2) Chemically inert, insoluble in water, resistant to acids, alkalis and solvents.
        3) Manufacturer and Product: Dow Chemical Company; Ethafoam 222.
    c. Fabric Backing:
        1) Cut and sewn into strips wide enough to overlap shop-coated areas by 4 inches on either side.

2) Strips shall have slots for steel strapping on outer edges.
3) Minimize diaper sagging under the haunches by using wide rubber support belts to fully support the diaper during mortar cure.

2.06 REPAIR OF COATINGS AND LININGS

A. General:

1. Coating or lining repair materials shall be compatible with the shop-applied coating or lining system and shall be approved by the coating or lining manufacturer.
2. All major repairs on coated steel pipe shall be with heat shrink sleeves in accordance with AWWA C216.
3. Coating repairs for exposed pipe shall be as specified herein.

B. Coating Repair Materials:

1. Heat Shrink Sleeves (Major Repair):
   a. Filler Mastic: Provide mastic filler to fill tape void as required.
   b. Full Wrap Coating: Cross-linked polyethylene wrap with a mastic sealant, 85-mil thickness minimum, suitable for pipeline operating temperature, sleeve material recovery as recommended by the manufacturer. Sleeve width shall provide a minimum of 2 inches overlap onto intact pipe coating.
   c. Manufacturers:
      1) Canusa.
      2) Raychem (Polyken).
      3) “Or-equal.”
2. Hand Tape-Applied Patches (Minor Repair):
   a. Hand tape-applied adhesive, polyolefin backed, mastic coated tape, 12 inches maximum size.
   b. Patch shall provide a minimum of 2 inches overlap onto intact pipe coating.
   c. CRP patch as manufactured by Canusa, PERP patch as manufactured by Raychem-Covalence, “Or-equal.”

C. Exposed Pipe Coating System: Touch-up repair all damage to the primer and/or intermediate coats with the specified coating system prior to final coating of the pipeline in accordance with Section 09 90 00, Painting and Coating.

PART 3 EXECUTION

3.01 GENERAL

A. Exterior and interior pipe and fitting surfaces shall be cleaned, primed, and coated in accordance with referenced standards, written directions of

the coating or lining manufacturer's, and these Specifications, whichever is more stringent.

B. Inspect and provide substrate surfaces prepared in accordance with referenced standards and these Specifications and the printed directions and recommendations of coating manufacturer whose product is to be applied.

C. Provide Engineer minimum 7 days' advance notice prior to start of surface preparation work or coating application work. Perform such work only in the presence of Engineer, unless Engineer grants prior approval to perform such work in Engineer's absence.

3.02 ENVIRONMENTAL CONTROLS

A. General:

1. Products shall comply with federal, state, and local requirements limiting the emission of volatile organic compounds and worker exposure.
2. Comply with applicable federal, state, and local, air pollution and environmental control regulations for surface preparation, blast cleaning, disposition of spent aggregate and debris, and coating application.
3. Do not perform abrasive blast cleaning whenever the relative humidity exceeds 85 percent, whenever surface temperature is less than 5 degrees above the dew point of the ambient air.
4. Do not apply coatings when:
    a. Surface and ambient temperatures exceeds the maximum or minimum temperatures recommended by the coating manufacturer or these Specifications.
    b. In dust or smoke-laden atmosphere, blowing dust or debris, damp or humid weather, or under conditions that could cause icing on the metal surface.
    c. When it is expected that surface temperatures would drop below 5 degrees above dew point within 4 hours after application of coating.
5. Where weather conditions or Project requirements dictate, Contractor shall provide and operate heaters and/or dehumidification equipment to allow pipe surfaces to be abrasive blasted and coated as specified and in accordance with the manufacturers coating application recommendations.
6. Work activities can be restricted by the Engineer until adequate temperature and humidity controls are in place and functioning within the environmental limits specified.

B. Temperature Control:

1. When temperatures are above or below the coating manufacturers recommended ambient, pipe, and coating material application temperatures, the Contractor will provide temperature controls to permit work to proceed within the temperature limitations of the Project.
2. Heating shall be with indirect fired heaters that do not increase humidity levels within the work area. Heaters shall be sized for the area to be heated.
3. Provide tenting, insulating blankets, baffles, or bulkheads as required to zone and control heating or cooling effectiveness.

C. Dehumidification:

1. Contractor shall provide dehumidification equipment when required for shop or field environmental control during surface preparation and/or coating application. Dehumidification equipment shall be properly sized to maintain dew point temperature 5 degrees or more below surface temperature of metal surfaces to be cleaned and coated.
2. Cleaned metal surfaces shall be prevented from flash rusting throughout the Project duration, condensation or icing shall be prevented throughout surface preparation and coating application.
3. Equipment size and power requirements shall be designed by personnel trained in the operation and setup of dehumidification equipment based on Project requirements and anticipated weather conditions.
4. Dehumidification equipment shall operate 24 hours per day and continuously throughout surface preparation and coating application.
5. Contractor to provide personnel properly trained in the operation and maintenance of the dehumidification equipment or provided training by the dehumidification equipment supplier.
6. Daily maintenance requirements of the equipment shall be documented in writing and posted near the equipment for review by the Engineer.
7. Reblasting of flash rusted metal surfaces or removal of damaged coatings, because of equipment malfunction, shutdown, or other events that result in the loss of environmental control, will be at the sole expense of the Contractor.

3.03 SURFACE PREPARATION

A. General:

1. Visible oil, grease, dirt, and contamination shall be removed in accordance with SSPC-SP1, solvent cleaning.
2. Surface imperfections such as metal slivers, burrs, weld splatter, gouges, or delaminations in the metal shall be removed by filing or grinding prior to abrasive surface preparation.
3. In cold weather or when moisture collects on the pipe and the temperature of the pipe is less than 45 degrees, preheat pipe to a temperature between 45 degrees and 90 degrees and 5 degrees above dew point.
4. Grit and shot abrasive mixture and gradation shall be as required to achieve the cleanliness and coating adhesion as specified.
5. Pipe cleaned by abrasive blasting with a mixture of steel grit and shot or other recycled abrasive shall be cleaned of debris and spent abrasive in an air wash separator.
6. Protect prepared pipe from humidity, moisture, and rain. Keep pipe clean, dry, and free of flash rust. All flash rust, imperfections, or contamination on cleaned pipe surface shall be removed by reblasting prior to primer application.
7. Priming and coating of pipe shall be completed in a continuous operation the same day as surface preparation.

B. Weld Surface Preparation:

1. Requirements:
   a. Spray applied coating systems do not require weld grinding.
   b. Welds on tape wrap coated pipe shall be either ground flush or a weld stripe tape applied over the weld, at the pipe fabricator's option, unless otherwise specified.
2. Weld Grinding: Under the weld grinding option, welds higher than 1/32 inch above pipe surface shall be ground to a tolerance of plus 1/32 inch to 0 inch above the pipe surface as measured on the lowest side of the weld.
3. Weld Stripe Tape:
   a. Weld stripe tape will be applied to primed metal.
   b. Tape will either have no polyethylene backing or will be double sided adhesive tape to permit adhesion of the inner corrosion protection layer to the weld stripe tape.
   c. Apply tape with a pressure roller to fully conform the tape to the weld surface.
   d. Adhesion of the weld stripe tape shall be as specified for the coating system.

C. Steel Surface Preparation:

1. Surface preparation of steel pipe shall be in accordance with SSPC surface preparation standards utilizing the degree of cleanliness specified for the coating system to be applied or as specified herein, whichever is more stringent.
2. Grit and/or shot abrasive mixture and gradation shall be as required to achieve the degree of cleanliness and coating adhesion specified.
3. Pipe cleaned by abrasive blasting with recyclable steel grit and/or shot or other abrasive shall be cleaned of debris and spent abrasive in an air wash separator.
4. Work shall be performed in a manner that does not permit the cleaned metal surface to rust back or flash rust.
5. Rust back or flash rust shall be fully removed with the steel surface cleanliness equal to the metal surface cleanliness prior to rust back or flash rusting. Determination of the equivalent surface cleanliness shall be at the Engineer's sole discretion.

3.04 SHOP-APPLIED COATING SYSTEMS

A. Tape Wrap Coating:

1. Applicator shall provide a monitoring system approved by the tape manufacturer that constantly records pipe and tape conditions during coating application. Recorded monitoring parameters shall include, but not be limited too, pipe temperature; line speed, primer and tape roll body temperature, and tape tension.
2. Pipe temperature shall be between 50 degrees and 120 degrees and 5 degrees above dew point during primer application.
3. Tape roll temperature shall be in accordance with the manufacturer's recommendations, but shall not be less than 70 degrees for the inner wrap and the outer wraps.
4. Apply a uniform coat of primer at the manufacturer's recommendations or as required for adhesion testing and without skips, runs, or sags. Allow to properly dry prior to applying the tape layers as required by the tape manufacturer to achieve maximum tape adhesion. Rug type primer application will not be allowed.
5. If welds are not ground flush, apply a weld stripe tape to all spiral or longitudinal pipe welds prior to application of the inner wrap. Application to be with a sufficient tension to assure adhesion to the weld and pipe surface.
6. Tape layers shall be applied continuously with the use of hydro-tension tape stands. Tension shall be maintained between the manufacturer's minimum and maximum tension recommendations or as required to achieve approximately 2 percent reduction in tape width.

7. A rubber pressure roller, wider than the tape width, shall be used on the inner tape layer to tape contact with the pipe surface.
8. The outer tape layers overlap shall be offset a minimum of 2 inches from the inner layer overlap.
9. Inner tape wrap shall adhere tightly to the pipe surface. Coating shall be 100 percent adhering to the metal surface and shall not have any visible damage, wrinkles, voids, disbondment, contamination, or holidays.
10. Tape coating adhesion testing shall be performed on the pipe as specified this section.
11. Holiday testing shall be conducted on the inner layer tape prior to proceeding with subsequent tape layers. All holidays detected shall be primed and patched using coating repair procedures specified herein.
12. Coating repairs shall be performed as specified this section.

B. Cement Mortar Overcoat:

1. Coated steel pipe, when specifically required, shall have a cement mortar overcoat applied over the exterior pipe coating in accordance with AWWA C205, except as modified herein.
2. Mortar coating shall be held back 3 inches, minimum, behind dielectric coating system cut back at joints.
3. Mortar Coating Reinforcement:
    a. Reinforce per AWWA C205. Alternately, reinforce with 2-inch by 4-inch mesh, per paragraph below.
    b. Lap ends of reinforcement strips 4 inches and tie or loop free ends to assure continuity of reinforcement.
    c. Special Fittings:
        1) Coating for steel plate specials may be reinforced with 2-inch by 4-inch No. 13 gauge welded wire mesh in lieu of reinforcing specified above.
        2) One layer of mesh shall be positioned approximately in center of coating for specials smaller than 48 inches in diameter.
    d. All steel wire reinforcement placed in the mortar coating shall be electrically isolated from the pipe. Electrical isolation will be tested by the manufacturer prior to shipment to the Project Site. See Inspection and Testing this section. Provide certification that electrical isolation of reinforcement wire from steel pipe.
4. Coating Defects:
    a. Cracking in the mortar “armor” coat less than 1/8-inch wide will be acceptable and do not require repair.

b. Disbondment of the cement coating over a dielectric coating system should be anticipated and will not be grounds for repair or rejection of the pipe.
c. Losses of cement mortar coating as a result of impact, movement, or shipping damage shall be repaired in accordance with AWWA C205.

3.05 HOLDBACKS AND CUTBACKS

A. Coating holdbacks shall be straight and cut through the full thickness of the coating, but not score or gouge the layer or substrate underneath.

B. Cutbacks shall be completed in a manner that permits field coating of joints in accordance with the manufacturer's recommendations and as specified herein. The tape wrap must protrude beyond the mortar coating a minimum of 3-inches.

C. Holdbacks shall be as shown on Drawings and as required for proper jointing of pipe, considering joint welding requirements, and be as follows:

Tape Wrap Coating	
Welded, spigot	3 inches, minimum from field weld
Welded, Bell	3 inches, minimum from field weld
Welded, Deep Bell	3 inches, minimum from field weld

D. Holdback Corrosion Protection:

1. Holding primer for corrosion protection of cutbacks or holdbacks shall be compatible with the specified joint coating system, when applicable.
2. Holdback coating shall prevent corrosion of prepared pipe ends for duration of storage and construction and shall be recommended for buried exposures.
3. Primer shall be compatible with welding operations and shall not result in running or melting of the coating during welding operations.
4. Application and thickness of holding primer shall be in accordance with the primer manufacturer's recommendations, but shall not impair the clearances required for proper joint installation.
5. Any corrosion within the holdback areas shall be abrasively blasted to near white metal in accordance with SP-10 or power tool cleaned to bare metal in accordance with SP-11 prior to applying joint coating.

3.06 PIPE LINING APPLICATION

A. Cement Mortar Lining: Cement mortar lining shall be in accordance with Section 33 05 01.01, Welded Steel Pipe and Fittings.

B. Epoxy Lining: Where indicated on Drawings vault piping shall be epoxy lined. Provide shop and field applied epoxy lining per System No. 1 as specified in Section 09 90 00, Painting and Coating.

3.07 FIELD COATING JOINTS

A. General:

1. Remove all oil or grease contamination by solvent wiping the pipe and adjacent coating in accordance with SSPC-SP-1, Solvent cleaning.
2. Clean pipe surface and adjacent coating of all mud, corrosion, and other foreign contaminates in accordance with SSPC-SP-11, Power Tool Cleaning to Bare Metal or abrasive blast joints in accordance with SSPC-SP-10, near white metal blast, that exhibit any surface corrosion or staining. When required, clean the full circumference of the pipe and a minimum of 6 inches onto the existing coating.
3. Remove all loose or damaged pipe coating at joint and either repair the coating as specified herein or increase the length of the joint coating, where reasonable and practical.
4. Complete joint bonding of pipe joints before application of joint coating. Joint bonds shall be installed as specified in Section 26 42 01, Pipe Bonding and Test Stations. Joint bonds shall be low profile bonds and all gaps and crevices around the bonds shall be filled with mastic sealant.
5. Contractor to electrically test every completed joint coating for holidays with megohmmeter, as in Article Shop-Applied Coating Systems. Each test shall be witnessed by the Engineer.

B. Post welded or “welded after backfill” joints are not allowed: Post-welded or “Weld after Backfill” joints are defined as welded pipe joints that have been coated and backfilled prior to completing interior welds.

C. Heat Shrink Sleeve Joint Coating:

1. Store, handle, and apply field heat shrink sleeve coatings in accordance with AWWA C216 and these Specifications.
2. Store sleeves in shipping box until use is required. Keep dry and sheltered from exposure to direct sunlight. Store off the ground or concrete floors and maintain at a temperature between 60 degrees and 100 degrees as recommended by the sleeve manufacturer.

3. Metal surface shall be free of all dirt, dust, and surface corrosion prior to sleeve application. Surface preparation shall be in accordance with the joint coating manufacturer's recommendations.
4. Where corrosion in the holdback area is visible, surfaces shall be prepared in accordance with SSPC-SP-10, near white metal blast, or SSPC-SP-11, power tool cleaning to bare metal.
5. Preheat pipe uniformly as recommended by the sleeve manufacturer. Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons. Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
6. Fill all cracks, crevices, gaps, and step-downs greater than 1/4 inch with filler mastic in accordance with the manufacturer's recommendations for the full circumference of the pipe.
7. Apply heat shrink sleeve when it is at a minimum temperature of 60 degrees and while maintaining the pipe temperature above the preheat temperature specified. Apply sleeve in accordance with the manufacturer's instructions and center the sleeve over the joint to provide a minimum 2-inch overlap onto the existing pipe coating.
8. Completed joint sleeve shall be fully bonded to the pipe and existing coating surface without voids. Mastic beading shall be visible along the full circumference of the sleeve. There shall be no wrinkling or excessive burns on the sleeves. Sleeves that do not meet these requirements shall be removed and the joint recoated as directed by the Engineer. Minor repairs may be repaired using heat applied patch material specified for minor coating repairs.
9. Allow the sleeve to cool before backfilling. In hot climates, provide shading from direct sunlight. Water quenching will be allowed only when permitted by the sleeve manufacturer.
10. Heat shrink joint coatings which have become wrinkled or disbonded because of prolonged exposure to UV light or thermal cycling shall be removed and replaced.
11. Double coating of defective or damaged heat shrink coatings will not be permitted. Any double coated heat shrink sleeves shall be immediately rejected and Contractor shall remove and recoat the joint.

D. Cement Mortar Coating:

1. Cement mortar coating shall be applied to the joints of cement mortar over coated steel pipe in accordance with AWWA C205.
2. Field repair cement mortar coating in accordance with AWWA C205.

3. Joint Diapers:
    a. Polyethylene Foam:
        1) Cut into strips wide enough to match uncoated field joint area.
        2) Slit to thickness of 1/4 inch that will expose a hollow or open cell surface on one side.
        3) Foam liner shall be attached to fabric backing with open or hollow cells facing towards pipe.
        4) Foam strip shall cover full interior circumference of grout band with sufficient length to permit 8-inch overlap of foam at or near top of joint.
        5) Splices to provide continuity of material will be permitted.
        6) Protect polyethylene foam material from direct sunlight.

3.08 REPAIR OF COATINGS AND LININGS

A. General:

1. All areas where holidays are detected or coating is visually damaged, such as blisters, tears, rips, bubbles, wrinkles, cuts, or other defects shall be repaired. Areas where no holidays are detected but are visually damaged shall also be repaired.
2. Maximum defects allowable shall be as specified herein for the coating system.

B. Tape Wrap Coating Repairs:

1. General:
    a. No more than five repairs per joint of pipe will be permitted with tape wrap coating, excluding adhesion testing damage. Any pipe with greater than five coating repairs or two areas or more of coating damage greater than 5 square feet will be rejected.
    b. Pipes exceeding the maximum number or size of coating defects shall be stripped, reblasted, and recoated.
    c. Pipe arriving in the field with defects or repairs exceeding the maximum number or size of coating defects will be returned to the shop for recoating at the Contractor's expense.
    d. The number of layers and total thickness of the tape repair coating shall be the same as the shop-applied coating; unless heat-applied coating materials is used.
    e. Wipe the area to be repaired with solvent for a minimum distance of 4 inches outside the damaged area.
2. Defect Size:
    a. Minor Repairs: Repairs that are less than 6 inches in the greatest dimension, measured after cutout of damaged tape

layers. Damage to the inner tape layer will be considered minor only if repairs are made using heat applied patch materials.

b. Major Repairs: Repairs that exceed 6 inches in the greatest dimension or where damage to the inner tape layer has occurred and hand applied tape repairs will be used.

3. Minor Repairs:
   a. Complete minor repairs using a heat applied coating patch material.
   b. Cut patch material to overlap onto the undamaged coating a minimum of 2 inches on all sides with 1-inch radius on each corner of the patch.
   c. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting or damaging the inner wrap.
   d. Cut middle and outer layers in stepped fashion to expose 1 inch or more of the underlying tape layer for the circumference of the repair.
4. Major Repairs (Over 24 Inches Diameter):
   a. Cigarette wrap coating repairs shall be with heat shrink sleeves as specified for joints.
   b. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting or damaging the inner wrap.
   c. Holiday test the inner wrap and if a holiday is detected, cut outer layers back to fully exposed the holiday(s) and retest for holidays.
   d. Cut middle and outer layers in stepped fashion to expose 1 inch or more of the underlying tape layer for the circumference of the repair.
   e. Width of sleeve shall be the width of the damaged area plus 4-inch overlap. Multiple sleeves may be used for larger repairs but must be overlapped a minimum of 2 inches.
5. Major Repairs (24-Inch Diameter or Less):
   a. Cigarette wrap repairs on pipe less than 24 inches with either hand applied tapes as specified or heat shrink sleeves as specified for major repairs on pipe over 24 inches in diameter at the Contractor's option.
   b. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting or damaging the inner wrap. Holiday test the inner wrap and if a holiday is detected, apply one extra layer of repair tape.
   c. Clean surfaces by solvent wiping and applying primer over the inner tape layer for a minimum of 6 inches onto the outer wrap in all directions.
   d. Apply first layer of repair coating, over lapping 4 inches or more onto undamaged coating in all directions. On larger areas, lap the repair tape within a minimum of 4-inch overlap,

offsetting the overlap from the previous layer overlap, until the area is properly covered.

e. Repeat for each tape layer damage with each succeeding layer applied at 90 degrees to the preceding layers and overlapping onto the undamaged coating a minimum of 2 inches.

f. Apply the last tape layer, use the cigarette wrap method for the full pipeline circumference covering all previous repair layers and overlapping a minimum of 2 inches onto undamaged coating. The ends of the cigarette wrap shall be pointed downward.

C. Cement Mortar Coating:

1. Cement mortar coating that is cracked or disbonded shall be repaired in accordance with AWWA C205, except for mortar overcoat on tape wrapped steel.
2. Disbonded mortar coating shall be removed and patched.
3. Mortar coating with disbondment greater than 25 percent of the pipe surface shall be rejected and recoated.
4. Cracks in mortar coating shall be repaired in accordance with AWWA C205.

3.09 INSPECTION AND TESTING

A. General:

1. Applicator shall inspect and test the coating system in accordance with referenced standards and these Specifications, whichever is more stringent.
2. The frequency of quality control testing shall be determined by the applicator but shall not be less than the requirements of this Specification.
3. Engineer will conduct random independent inspections and tests for the final acceptance or rejection of the pipe coating or lining.

B. Adhesion Testing:

1. General:
   a. Adhesion testing shall be conducted at the shop prior to shipment. Pipe shipped without adhesion testing will be field tested. Pipe rejected in the field will be returned to the shop for repair at the sole expense of the Contractor.
   b. A minimum of two pipes will be tested for adhesion from each lot of pipe coated up to 4,000 square feet of pipe. An additional adhesion test will be conducted on every increment up to 3,000 square feet of pipe coated in excess of the first 4,000 square feet of pipe (for example, if one workday of

production is 8,000 square feet of pipe, four adhesion tests will be conducted on the pipe lot).

1) If less than 10 percent of adhesion tests in 5 consecutive working days fail, reduce testing rate to two pipes per day regardless of pipe quantity coated. If while testing two joints per day, more than two adhesion tests fail within 5 consecutive working days, resume the testing frequency in paragraph above.

c. A pipe lot is defined as the quantity of pipe that is coated by a single crew within a normal 8-hour workday.

d. The pipe coating applicator shall repair all coating damage from adhesion testing.

e. Adhesion tests will be performed not less than 24 hours after coating application. Tests conducted prior to 24 hours will be acceptable only if the test meets or exceeds the adhesion criteria specified and the test was requested by the pipe fabricator.

f. Pipe will be randomly selected for adhesion testing.

g. If any pipe tested fails the adhesion test, all pipes within the lot will be rejected. Each pipe within the rejected pipe lot will then be individually tested for adhesion and rejected on a pipe-by-pipe basis.

2. Tape Coating Adhesion Testing:

a. Inner tape coating shall have an adhesion to steel of 20 pounds per inch width, minimum, when tape is pulled in a continuous manner at an angle of 180 degrees to the pipe surface.

b. Tape adhesion testing shall be conducted prior to application of the cement mortar overcoat. Pipe that has been mortar coated prior to adhesion testing shall have the mortar coating removed by the Contractor as directed by the Engineer and of sufficient dimensional area to permit the adhesion test to be conducted.

c. Adhesion tests shall be conducted at temperatures above 60 degrees and less than 75 degrees.

d. Failure shall be by cohesive failure of the adhesive only. Delamination failure, defined as separation of the adhesive from the backing material, will result in rejection of the tape lot. Intermittent skip failures will be counted as zero pounds of adhesion and included in the calculations for average coating adhesion.

e. Pipe that fails the test by delamination will be retested on two other pipes with the same lot of tape. Failure of any two pipes within the lot will result in rejection of all pipes coated with the rejected tape lot.

f. Pulling tension shall be continuous, without stopping, and monitored throughout the length of the pull, which shall be not less than 12 inches in length.

g. The pull tension shall be recorded for each inch of pull. The two highest and two lowest readings shall be discarded and the remaining values averaged. Pull speed shall be not less than 5 seconds per inch or greater than 10 seconds per inch. If elongation of the tape backing occurs, pull speeds may exceed 10 seconds per inch provided the minimum adhesion rating can still be achieved.
h. Pull test area shall be patched immediately following the pull test.

C. Holiday Testing:

1. Tape Wrap Coatings: Holiday test the inner layer of tape after application and prior to the subsequent tape layer in accordance with AWWA C214 and NACE Standard RP-0274.

D. Dry Film Thickness Testing:

1. Coatings shall be tested for dry film thickness using a properly calibrated magnetic pull off or eddy current equipment.
2. Coating thickness measurements shall be conducted as necessary and without limitation. Testing conformance to the requirements of SSPC-PA-2 is specifically excluded from this Specification.

E. Cement Mortar Overcoat Reinforcing Wire Electrical Isolation:

1. All steel wire reinforcement placed in the mortar coating shall be electrically isolated from the pipe.
2. Wire electrical isolation shall be tested at both ends of the pipe segment using a megohmmeter. If either test is less than 100 ohms in resistance, the wire is considered electrically continuous with the pipeline and does not meet the test.
3. If the wire cannot be isolated the pipe segment shall be rejected.
4. Provide certification that electrical isolation of reinforcement wire from steel pipe has been met.

3.10 HANDLING, TRANSPORTATION, AND STORAGE

A. Pipe shall be handled in accordance with AWWA C214 and in such a manner as to protect the pipe and coating from damage.

B. Handling equipment, materials, and procedures shall be submitted for approval by the Engineer.

C. Coated pipe shall not be shipped or installed until coating has developed full adhesion and cure.

D. During coating application, storage, loading, transportation, unloading, laying and installation, every precaution shall be taken to protect and prevent damage to pipe, lining, and coating. Forklift equipment shall have all bearing surfaces padded with suitable padding material. Lift pipe with web slings a minimum of 18-inch wide and of a type that will not damage the coating. Metal chains, cable, tongs, forklifts or other equipment likely to damage the coating will not be permitted. Dragging or skidding of pipe on grade or in the trench will not be permitted.

E. Provide transportation vehicles with padded bolsters between each layer of pipe and heavy padding under load ties. Bolsters shall be curved to fit the outside of the pipe and 12 inches wide, minimum. All pipe contact locations shall be heavily padded with carpet and strips of the outer tape wrap material (adhesive side against the carpet) during shipment to the Project Site and from the storage yard to the point of installation.

F. Pipe shall not be stored on rocks, gravel, or other hard materials that might damage the coating. Provide padded 12-inch wide skids and chucks, sand bags, select loamy or sand berms, or suspended from cutback ends, where possible, to minimize coating damage. Pipe shall not be laid on asphalt without suitable padding at all contact points.

G. Pipe shall be inspected by the Contractor at the Project Site for damage. Any damage to the pipe, lining, or coating shall be repaired as directed if, in the opinion of the Engineer, a satisfactory repair can be made; otherwise, the damaged section shall be replaced at the sole expense to the Contractor.

H. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workmen shall not be permitted to walk on the coating except when absolutely necessary and approved by the Engineer. When permitted, shoes with rubber or composition soles and heels or other suitable footwear that will not damage coating shall be used.

I. Long-term Exposure: Pipe shall either be provided with UV inhibitor for lengthy above grade exposure or covered to prevent UV degradation of outer wrap. Amount of UV stabilizers required will depend on the Project location, laying schedule, anticipated length of exposure, and type of outer wrap. Manufacturer shall be consulted for recommended UV inhibitors requirements or pipe shall be stored under a protective cover. Protective covering can be colored plastic sheeting, canvas, or other UV blocking material. Clear plastic sheets are not acceptable. Areas of coating that display UV degradation shall be removed and repaired at sole cost of the Contractor.

J. End Caps: Pipe ends of lined pipe and fittings shall be tightly closed with a plastic wrap to aid in curing and to minimize drying out of and contamination of the lining. Plastic end cap shall consist of a minimum of one 10-mil sheet of polyethylene or other suitable material. End caps shall be substantial enough to resist shipment, handling, and storage loads and firmly attached in place. The plastic end cap shall remain intact and in place until pipe installation. Damaged or missing plastic end caps shall be repaired or replaced.

K. Stulling and Bracing: As specified in Section 33 05 01.01, Welded Steel Pipe and Fittings.

END OF SECTION

SECTION 09 96 00
TEXTURED ACRYLIC FINISHES (TAFS)

PART I GENERAL

1.01 SURFACES REQUIRING TAF

A. Apply Textured Acrylic Finish (TAF) to exterior wall faces of Building 70 Structure and its roll-up door enclosures from top of parapet to finished grade. Surfaces are shown with a 1/2-inch deep “V” groove pattern as indicated on Drawings.

1.02 SUBMITTALS

A. Product Data: Provide manufacturer’s product data sheets.

B. Samples: Provide two samples of each finish, texture, and color to be used on the Project. The same tools and techniques proposed for the actual installation shall be used to prepare the samples. Samples shall be of sufficient size to accurately represent each color and texture to be utilized on the Project.

C. Test Reports: Provide copies of selected test reports verifying the performance of the system materials.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. All materials shall be manufactured or sold by a single manufacturer and shall be purchased from the manufacturer’s authorized distributor.
    a. Materials shall be manufactured at a facility covered by a current ISO 9001:2000 certification. Certification of the facility shall be done by a registrar accredited by the American National Standards Institute, Registrar Accreditation Board (ANSI-RAB).
2. Contractor: Knowledgeable in the installation of the materials and experienced and competent in the application of Textured Acrylic Finishes. Additionally, the contractor must possess a current trained contractor certificate from the manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered to the Job Site in the original, unopened packages with labels intact.

B. Upon arrival, materials shall be inspected for physical damage, freezing, or overheating. Questionable materials shall not be used.

1. Materials shall be stored at the Job Site in a cool, dry location, out of direct sunlight, protected from weather and other sources of damage. Minimum storage temperature shall be as recommended by the manufacturer.

C. Protect all products from inclement weather and direct sunlight.

1.05 PROJECT CONDITIONS

A. Environmental Requirements:

1. Application of wet materials shall not take place during inclement weather unless appropriate protection is provided. Protect materials from inclement weather until they are completely dry.
2. At the time of application, the minimum air and wall surface temperatures shall be as recommended by the manufacturer.
3. These temperatures shall be maintained, with adequate air ventilation and circulation, for a minimum of 24 hours thereafter, or until the products are completely dry. Refer to published product data sheets for more specific information.

B. Existing Conditions: The Contractor shall have access to electric power, clean water, and a clean work area at the location where the materials are to be applied.

1.06 SEQUENCING AND SCHEDULING

A. Installation of the Textured Acrylic Finishes shall be coordinated with other construction trades.

B. B. Sufficient manpower and equipment shall be employed to ensure a continuous operation, free of cold joints, scaffold lines, texture variations, etc.

1.07 1.06 WARRANTY

A. The manufacturer shall provide a written, 10-year limited materials warranty against defective materials, upon written request.

B. The applicator shall warrant workmanship.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland Cement: Shall be Type I or Type II, meeting ASTM C150, white or gray in color, fresh and free of lumps.

B. Water: Shall be clean and free of foreign matter.

C. Performance Requirements as:

1. Durability:

TEST	TEST METHOD	CRITERIA	RESULTS
Abrasion Resistance	ASTM D968	No deleterious effects after 500 liters (528 quarts)	No deleterious effects after 1,000 liters (1,056 quarts)
Accelerated Weathering	ASTM G155 Cycle 1	No deleterious effects after 2,000 hours	No deleterious effects after 5,000 hours
	ASTM G154 Cycle 1 (QUV)		No deleterious effects after 5,000 hours
Freeze-Thaw	EIMA 101.01	No deleterious effects after 60 cycles	Passed - No deleterious effects after 90 cycles
	ASTM C67 modified	No deleterious effects after 60 cycles	Passed - No deleterious effects after 60 cycles
	ICC ES Procedure	No deleterious effects after 10 cycles	Passed - No deleterious effects after 10 cycles
Mildew Resistance	ASTM D3273	No growth during 28 day exposure period	No growth during 60 day exposure period
Moisture Resistance	ASTM D2247	No deleterious effects after 14 days exposure	No deleterious effects after 42 days exposure
Taber Abrasion	ASTM D4060	N/A	Passed 1,000 cycles
Salt Spray Resistance	ASTM B117	No deleterious effects after 300 hours exposure	No deleterious effects after 1,000 hours exposure

2. Fire Performance:

TEST	TEST METHOD	CRITERIA	RESULTS
Flame Spread	ASTM E84	All components shall have a Flame Spread Index ≤ 25 Smoke Developed Index ≤ 450	Passed

2.02 COMPONENTS

A. Primers and Adhesion Promoter:

1. Color Prime: Pigmented, acrylic based primer used to improve adhesion and uniformity of finish color.

B. Finish:

1. Water-based, acrylic coating with integral color and texture and formulated with Dirt Pickup Resistance (DPR) chemistry.
2. Sandblast DPR: Medium texture

C. Color: As indicated on Color List on Drawings.

2.03 MANUFACTURER AND PRODUCT

A. Dryvit Systems, Inc.; TAFS, Sandblast.

B. “Or-equal.”

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to the installation of the TAFS, confirm that all needed flashings and other waterproofing details have been completed, if such completion is required prior to the application of the TAFS.

B. Notify the owner of all discrepancies. Work shall not proceed until discrepancies have been corrected.

3.02 SURFACE PREPARATION

A. The substrates shall be prepared so as to be free of foreign materials such as oil, dust, dirt, form-release agents, efflorescence, paint, wax, water repellents, moisture, frost and any other materials that inhibit adhesion.

B. Concrete: Shall be dry and cured a minimum of 28 days.

3.03 INSTALLATION

A. The materials shall be mixed and applied in accordance with current manufacturer's printed product data sheets.

B. Poured in Place and Precast Concrete Surfaces:

1. Using a brush, roller, or airless spray equipment, apply a coat of Color Prime over the dry base coat or cleaned substrate, and allow it to dry.
2. Apply the specified finish in accordance with the manufacturer's printed installation instructions for the specific finish being used.

3.04 FIELD QUALITY CONTROL

A. The Contractor shall be responsible for the proper application of the TAFS.

3.05 CLEANING

A. All excess materials shall be removed from the Job Site by the Contractor in accordance with Contract provisions and as required by applicable law.

B. All surrounding areas, where TAFS have been installed, shall be left free of debris and foreign substances resulting from the Contractor's work.

3.06 PROTECTION

A. TAFS shall be protected from weather and other sources of damage until dry and permanent protection in the form of flashings, sealants, etc. are installed.

END OF SECTION

SECTION 10 44 00
FIRE PROTECTION SPECIALTIES AND SAFETY EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Fire Protection Association (NFPA): 10, Standard for Portable Fire Extinguishers.
2. Underwriters Laboratories Inc. (UL): Fire Protection Equipment Directory.

1.02 PERFORMANCE REQUIREMENTS

A. Conform to NFPA 10 and 2018 International Building Code.

B. Provide extinguishers classified and labeled by Underwriters Laboratories Inc. for purpose specified and indicated.

C. Provide key boxes as required by the applicable code or by the fire marshal or code official having jurisdiction.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Fire Extinguishers: Manufacturer's product data for each item, including sizes, ratings, UL listings, or other certifications, and mounting information.
   b. Key Boxes: Indicate type of cabinet, cabinet physical dimensions, rough-in measurements for recessed mounting methods and anchorage details.
   c. Product Data: Submit for all other specified items.

B. Informational Submittals:

1. Manufacturer's Installation Instructions: Special criteria requirements.
2. Operation and Maintenance Data: Submit test, refill or recharge schedules and recertification requirements.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Section 01 61 00, Common Product Requirements: Environmental conditions affecting products onsite.

B. Do not install extinguishers when ambient temperatures are capable of freezing extinguisher ingredients.

PART 2 PRODUCTS

2.01 PORTABLE FIRE EXTINGUISHERS

A. Manufacturers:

1. JL Industries.
2. Larsen's Manufacturing Co.
3. Nystrom Products Co.

B. General:

1. Conform to NFPA 10 for fire extinguishers.
2. Furnish fire extinguishers and cabinets from one manufacturer.
3. UL listed, charged and ready for service.

C. Multipurpose Hand Extinguisher (F. Ext-1):

1. Tri-class dry chemical extinguishing agent.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Agent propelled through hose or opening at top of unit.
5. For use on A, B, and C class fires.
6. Minimum UL Rating: 4A-60B:C, 10-pound capacity.

2.02 KEY BOXES

A. Manufacturers and Products:

1. Knox Company, Phoenix, AZ.
2. Kidde Fire Safety; SupraSafe, Mebane, NC.

B. Steel high-security commercial key vault, basis of design:

1. KnoxBox® 3200.
2. Color: Dark Bronze, Model 3274.
3. UL listed; and resists moisture and weather by use of a gasketed exterior door. Unit is to be recessed into exterior wall using special mounting kit.

2.03 FIRST-AID CABINETS AND SUPPLIES

A. Manufacturers:

1. Afassco, Inc.
2. Johnson & Johnson.
3. Zee Medical Products Co., Inc.

B. Cases:

1. Enameled metal or break-resistant plastic.
2. Carrying handles.
3. Made to hang on wall.

C. Supplies: Quantities to serve 20 people.

2.04 ACCESSORIES

A. Extinguisher Brackets: Furnish heavy-duty, formed steel with white enamel finish brackets with clip-together strap for wall mounting.

B. Fasteners: Furnish necessary screws, bolts, brackets, and other fastenings of suitable type and size to secure items of fire and safety equipment in position.

1. Metal expansion shields for machine screws at concrete and masonry.
2. Interior: Rust-resistant.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install where indicated or directed and in accordance with manufacturer's recommendations.

B. Install plumb and level.

C. Secure cabinets and brackets rigidly to structure.

D. Provide adequate backing for mounting surfaces.

E. Place extinguishers and accessories on wall brackets.

3.02 PORTABLE FIRE EXTINGUISHERS

A. Provide at locations shown or as directed by Engineer.

B. Mount hangers securely in position, following manufacturer's recommendations.

C. Top of Extinguisher: No more than 54 inches above floor.

D. Install wall brackets, maximum 48 inches from finished floor to top of extinguisher handle.

3.03 KEY BOX:

A. Mount bottom of box 5 feet 0 inches AFF but is subject to approval by AHJ. Consult local Fire Department.

3.04 FIRST-AID CABINETS AND SUPPLIES (FAC)

A. Provide at locations shown on Drawings or where directed by Engineer.

END OF SECTION

SECTION 22 30 00
PLUMBING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA).
2. American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. American Society of Mechanical Engineer's (ASME).
4. American Society of Sanitary Engineering (ASSE):
   a. 1013, Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Backflow Preventers.
   b. 1015, Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Backflow Fire Protection Assemblies.
5. American Water Works Association (AWWA):
   a. C510, Double Check Valve Backflow Prevention Assembly.
   b. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   c. C550, Protective Interior Coatings for Valves and Hydrants.
6. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
7. Canadian Standards Association (CSA):
   a. B64.4, Backflow Preventers, Reduced Pressure Principle Type (RP).
   b. B64.5, Backflow Preventers, Double Check Valve Type (DCVA).
8. FM Global (FM).
9. Food and Drug Administration (FDA).
10. Foundation for Cross-Connection Control and Hydraulic Research at University of Southern California (FCCHR): Manual of Cross-Connection Control.
11. International Code Council (ICC): International Plumbing Code (IPC).
12. National Electrical Code (NEC).
13. National Electrical Manufacturers Association, (NEMA): MG 1, Motors and Generators.

14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. UL.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's product data.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Performance test report for submersible pump.

1.03 SPECIAL GUARANTEE

A. Where note below, provide manufacturer's extended guarantee in writing with Owner named as beneficiary. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of products found defective during the stated period after date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SUBMERSIBLE CENTRIFUGAL SUMP PUMPS

A. Duplex, Submersible Sump Pump:

1. Construction:
   a. Impeller and Volute: Nonclog design, ASTM A48/A48M, Class 30, cast iron capable of passing 1/2-inch spherical solid.
   b. Electrical: Water-resistant, UL listed and CSA approved electrical power cord.
   c. Motor: Sealed, oil-filled, NEMA B design with winding thermal sensors.
   d. Bearings and Shaft: Upper and lower thrust bearings, solid Type 303 stainless steel shaft.
   e. Seals: Two mechanical seals, carbon rotating seal face and ceramic stationary seal face, and lower seal failure sensor and warning device.
2. Controller:
   a. Control Panel: Fabricated steel, NEMA 4 enclosure, door disconnect switch, and bear UL listing mark. Components shall bear UL recognized marking. Wiring, schematics, and workmanship shall comply with NEC and UL.
   b. Wiring and Conduit: Minimum of MTH, 600V rated, 18-gauge with 90 degrees C rating, in accordance with NEC standards. Wire sized in accordance with NEC standards.
   c. Motor Protection: Magnetic motor starter, across the line type, UL listing mark, under voltage and over voltage protection with manual reset button mounted in panel door.
   d. Level Sensors (Duplex): Automatic pump cycle and alternation. Polypropylene encapsulated mechanical level sensors for pump on, pump off, and override (standby pump on). Additional level sensor shall activate audible-visual panel mounted light and horn. Panel mount, push-to-silence button for deactivating audible alarm.
   e. Provide the following 120V, 2A rated dry contacts for remote monitoring by SCADA system:
      1) High Level alarm.
      2) Pump 1 running status.
      3) Pump 2 running status.
3. Capacity: See data sheet at end of section.
4. Manufacturers:
   a. Hydromatic Pumps.
   b. Paco Pump.
   c. Weil Pump Company, Inc.
   d. “Or-equal.”

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, arrange, and connect equipment as shown on Drawings and in accordance with manufacturer's recommendations.

3.02 FIELD QUALITY CONTROL

A. Pumps: Do not hydrostatic test pumps with mechanical seals.

B. Startup:

1. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

3.03 SUPPLEMENT

A. Supplement listed below, following "End of Section," is a part of this Specification.

1. Data Sheet: Duplex, Submersible Sump Pump.

END OF SECTION

Duplex, Submersible Sump Pump						
Sump Pump:						
Tag Number	Flow Rate (gpm)	Pressure (feet head)	Motor (hp)	Motor Speed (rpm)	Power (volts/phase)	Manufacturer, Model No.
ALL	30	15		1750	120V/1ph	

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. Z535.4, Product Safety Signs and Labels.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.03 DESIGN REQUIREMENTS

A. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.

1.04 ELECTRIC SERVICE DIVISION OF RESPONSIBILITY

A. Incoming aerial or underground electrical service facilities provided by the serving utility as part of its normal obligation to customers is work provided outside this Contract. Under this Contract, provide customer required service provisions and electrical work including, but not limited to, primary trench and backfill, primary duct system, transformer pad site preparation, transformer pad, metering components and associated conduit, secondary facilities, and all additional work required by the Utility providing service. Schedule and coordinate work of serving utility as required to provide electric service to the Work.

1.05 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Electrical service components.
   b. Nameplates, signs, and labels.
2. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

B. Informational Submittals: Anchorage and bracing calculations, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

1.06 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.07 ENVIRONMENTAL CONDITIONS

A. See Environmental Conditions Table Supplement for environmental conditions specific to this Project.

PART 2 PRODUCTS

2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

D. Electrical ratings of materials and equipment that are reduced by increased elevation shall be derated as required for Site elevation specified in Section 01 61 00, Common Product Requirements.

2.02 EQUIPMENT FINISH

A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with Section 09 90 00, Painting and Coating, light gray color finish as approved by Owner.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws:

1. Stainless steel.
2. Adhesive: Single-part, room temperature vulcanizing adhesive suitable for the environment and materials installed. Use adhesive on NEMA 4 or NEMA 4X enclosures only.

C. Color: Black, engraved to a white core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8 inch.
2. Other Electrical Equipment: 1/4 inch.

2.04 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING, BRACING, AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for Project design criteria provided in Section 01 61 00, Common Product Requirements, to meet the requirements of Section 01 88 15, Anchorage and Bracing.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

1. Field mark switchboards, motor control centers, panelboards, automatic transfer switches, switchgear, and padmount transformers, to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.
2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from study required in Section 26 05 70, Electrical Systems Analysis as basis for warning signs.

B. Available Fault Current Signs:

1. Install label on service equipment to indicate the maximum available fault current at the equipment. Labels shall be of sufficient durability for the environment in which the equipment is installed. Labels shall include the following information:
   a. Equipment name or identification.
   b. Available fault current at the equipment.
   c. Date the fault current calculations were performed.
2. Use bolted fault current and equipment name from study required in Section 26 05 70, Electrical Systems Analysis, or from Engineer as basis for the label.
3. Where existing electrical systems are modified, completely remove existing fault current labels if present, and install new labels in accordance with the above requirements.

C. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.

D. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

3.08 SUPPLEMENT

A. The supplement listed below, following "End of Section," is part of this Specification.

1. Environmental Conditions Table.

END OF SECTION

ENVIRONMENTAL CONDITIONS TABLE						
Project Areas	Class I, Division 1	Class I, Division 2	Corrosive	Nonhazardous and Wet	Indoor and Dry	Dry and Industrial
Outdoor				x		
Area 1			x			
Area 2					x	
Area 3		x				
Area 4						x
Area 5	x					
Other Areas						x

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
   b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C12.1, Code for Electricity Metering.
   c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
   d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL:
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.

h. 1059, Standard for Terminal Blocks.
i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Intrinsic safety barriers.
   j. Firestopping.
   k. Enclosures: Include enclosure data for products having enclosures.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 Volt to 600 Volts: Six of each type and each current rating installed.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
8. Circuit Breakers with Frames 400 Amperes and Greater: Provide solid state trip unit.
   a. In accordance with UL 489.
   b. Main and feeder protective device.
   c. UL labeled as suitable for service entrance, where shown.
   d. Molded case breaker with ambient insensitive solid-state trip and having current sensors and logic circuits integral in breaker frame.
9. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.

D. Short Circuit Interrupting Ratings:

1. Breakers installed in new equipment or enclosures: Equal to, or greater than, available fault current or interrupting rating shown for new equipment.
2. Breakers installed in existing Equipment: Equal to rating of existing equipment.
3. If no rating is shown, breaker shall be rated for 65,000 amps interrupting current.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

I. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

J. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Enclosures: See Article Enclosures.

E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.
3. Manufacturers and Products:
   a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
   b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
   a. Bussmann; Type KRP-C.
   b. Littelfuse, Inc.; Type KLPC.

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann.
   b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: Push-to-test, LED, full voltage.

D. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64 inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. ABB; Type CR 104P.
   b. Schneider Electric; Type K.
   c. Eaton Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Schneider Electric; Type SK.
   b. ABB; Type CR 104P.
   c. Eaton; Type E34.

2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Phoenix Contact.
2. Ideal.
3. Electrovert USA Corp.
4. Allen-Bradley.

2.07 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. Accessories:

1. Push-to-test button.
2. Relay status LED.

C. Mounting: Din rail or panel.

D. Manufacturers and Products:

1. Eaton; Type D3PR.
2. General Electric Co.
3. Square D; Type F.
4. General Electric Co.
5. Allen-Bradley.

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3600VA make, 360VA break.

B. Solid-state electronic, field convertible ON/OFF delay.

C. One normally open and one normally closed contact (minimum).

D. Repeat accuracy plus or minus 2 percent.

E. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

F. Manufacturers and Products:

1. Eaton; Type TR.
2. Square D Co.; Type F.
3. ABB; CT-C.

2.09 MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:

1. Power driven in one direction with mechanical spring dropout.
2. Silver alloy with wiping action and arc quenchers.
3. Continuous-duty, rated as shown.
4. Poles: As shown.

D. Control: As shown.

E. Auxiliary Contacts: One normally open and one normally closed, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See Article Enclosures.

G. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

2.10 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in CLOSED position.

D. Main Contacts:

1. Double-break, continuous-duty, rated 30 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts, or 14,000 amps rms symmetrical at 480 volts.
2. Marked for electric discharge lamps, tungsten, and general purpose loads.
3. Position not dependent on gravity, hooks, latches, or semi-permanent magnets.
4. Capable of operating in any position.
5. Visual indication for each contact.

E. Auxiliary contact relay for two-wire control.

F. One normally open and one normally closed auxiliary contact rated 10 amperes continuous, 7,200VA make, 720VA break with NEMA designation of A600 (600 volts).

G. Fully rated neutral terminal.

H. Provision for remote pilot lamp with use of auxiliary contacts.

I. Clamp type, self-rising terminal plates for solderless connections.

J. Enclosures: See Article Enclosures.

K. Manufacturers and Products:

1. ASCO.
2. Eaton/Cutler-Hammer; Class A202.
3. General Electric Co.; CR460 Series.
4. Square D; Class 8910.

2.11 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.12 INTRINSIC SAFETY BARRIER

A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.

B. Rating: Power source shall be rated 24 volts dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250 volts ac.

D. Mounting: Rail or surface.

E. Manufacturers and Products:

1. MTL, Inc.; Series 2000 or Series 3000.
2. R. Stahl, Inc.

2.13 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer: U.S. Mat and Rubber Company.

2.14 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by UL, or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.

2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

2.15 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections:

1. Except as shown otherwise, provide electrical enclosures according to the following table:

Enclosures			
Location	Finish	Environment	NEMA 250 Type
Indoor	Finished	Dry	1
Indoor	Unfinished	Dry	1
Indoor	Unfinished	Industrial Use	12
Indoor and Outdoor	Any	Wet	4X
Indoor and Outdoor	Any	Denoted "WP"	3R
Indoor and Outdoor	Any	Wet and Corrosive	4X 316 stainless steel
Indoor and Outdoor	Any	Wet, Dust or Oil	13

Enclosures			
Location	Finish	Environment	NEMA 250 Type
Indoor and Outdoor	Any	Hazardous Gas	7
Indoor and Outdoor	Any	Hazardous Dust	9

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.

B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. PVC-Coated Conduit: PVC coated.
   b. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. PVC Conduit: Type 316 stainless steel or nonmetallic.
   b. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel
3. Outdoor, Noncorrosive Locations:
   a. Steel Raceway: Carbon steel, except where mounted on aluminum handrail, then use aluminum framing channel.

4. Outdoor Corrosive Locations:
   a. PVC Conduit: Type 316 stainless steel or nonmetallic.
   b. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel.
5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. PVC-Coated Channel: PVC patch.

3.04 INTRINSIC SAFETY BARRIERS

A. Install in compliance with ISA RP12.06.01.

B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.

C. Stencil “INTRINSICALLY SAFE CIRCUIT” on all boxes enclosing barriers.

3.05 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

3.06 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
   a. B3, Standard Specification for Soft or Annealed Copper Wire.
   b. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   c. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
   b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
   e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. UL:
   a. 13, Standard for Safety for Power-Limited Circuit Cables.
   b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
   c. 62, Standard for Safety for Flexible Cord and Cables.
   d. 486A-486B, Standard for Safety for Wire Connectors.
   e. 486C, Standard for Safety for Splicing Wire Connectors.
   f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety for Service-Entrance Cables.
   h. 1072, Standard for Safety for Medium-Voltage Power Cables.
   i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   j. 1569, Standard for Safety for Metal-Clad Cables.
   k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Wire and cable.
   b. Wire and cable accessories.
   c. Cable fault detection system.
2. Manufactured Wire Systems:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fittings.
3. Busway:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fitting.
   e. Equipment interface information for equipment to be connected to busways.

4. Cable Pulling Calculations:
   a. Ensure submitted and reviewed before cable installation.
   b. Provide for the following cable installations:
      1) Medium voltage cable runs that cannot be hand pulled.
      2) All cable pull lengths longer than 400 feet.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by journeyman lineman with splicing credentials or electrician certified to use materials approved for cable splices and terminations.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: shielded, UL 1072, Type MV-105.
3. Voltage Rating: As noted on Drawings.
4. Conductors: Aluminum, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
5. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 8.
6. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 71, and AEIC CS 8.
7. Insulation Nominal Thickness:
   a. 5kV, 115-mil.
   b. 8kV, 140-mil.
   c. 15kV, 220-mil.
8. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
9. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 12-1/2 percent minimum overlap.
10. Jacket: Extruded polyvinyl chloride (PVC)compound applied in accordance with NEMA WC 71 or NEMA WC 74.
11. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
12. Manufacturers:
    a. Okonite Co.
    b. Pirelli Wire and Cable.
    c. General Cable.
    d. Southwire Co.

2.03 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

3. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. Type 2, Multiconductor Power Cable:

1. General:
   a. Meet or exceed UL 1581 for cable tray use.
   b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
   c. Overall Jacket: PVC.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
   c. UL rated VW-1 or listed Type XHHW-2.
   d. Cable Assembly, Color Code:
      1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.
3. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45
10	10	2 3 4	0.54 0.58 0.63	60
8	10	3 4	0.66 0.75	60
6	8	3 4	0.74 0.88	60
4	6	3 4	0.88 1.04	60 80
2	6	3 4	1.01 1.16	80
1	6	3 4	1.10 1.25	80
1/0	6	3 4	1.22 1.35	80

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
2/0	4	3 4	1.32 1.53	80
3/0	4	3 4	1.40 1.60	80
4/0	4	3 4	1.56 1.78	80 110

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.

4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand, tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

F. Type 5, 18 AWG, Multi-twisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wires.
   c. Pair drain wire size AWG 20, group drain wire size AWG 18.
   d. Insulation: 15-mil PVC.
   e. Jacket: 4-mil nylon.
   f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
   g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

G. Type 7, Multiconductor Metal-Clad (UL Type MC) Power Cable:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	12 or 3x16	3 4	0.79 0.85	50
10 AWG	10 or 3x14	3 4	0.82 0.90	50
8 AWG	10 or 3x14	3 4	0.85 1.00	50
6 AWG	8 or 3x12	3 4	0.99 1.10	50
4 AWG	8 or 3x12	3 4	1.08 1.20	50
2 AWG	6 or 3x10	3 4	1.24 1.45	50
1 AWG	6 or 3x10	3 4	1.40 1.55	50
1/0 KCM	6 or 3x10	3 4	1.52 1.60	50
2/0 AWG	4 or 3x8	3 4	1.67 1.75	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
4/0 AWG	4 or 3x8	3 4	1.93 2.10	60
250 KCM	4 or 3x8	3 4	2.11 2.20	60
350 KCM	3 or 3x8	3 4	2.39 2.50	60
500 KCM	2 or 3x8	3 4	2.80 2.90	75

7. Manufacturers and Products:
   a. Okonite Co.; Type CLX.
   b. Southwire Type MC.
   c. General Cable, CCW Armored Power.

H. Type 8, Multiconductor Adjustable Frequency Drive Power Cable:

1. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
   c. Grounding Conductors: Insulated stranded copper.
2. Sheath:
   a. UL 1277 Type TC, 90 degrees C.
   b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
12 AWG	12	4	0.655	50
10 AWG	10	4	0.769	50
8 AWG	8	4	0.940	50
6 AWG	6	4	1.038	50
4 AWG	4	4	1.180	50
2 AWG	2	4	1.351	50

5. Manufacturers and Products:
   a. Alpha Wire; Series V.
   b. Belden; Series 29500.
   c. LAPP USA; OLFLEX VFD Slim.

I. Type 9, Multiconductor Metal-Clad (UL Type MC) Power Cable for Adjustable Frequency Drive Applications:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper. Provide three symmetrical grounding conductors.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	3x16	3 4	0.79 0.85	50
10 AWG	3x14	3 4	0.82 0.90	50
8 AWG	3x14	3 4	0.85 1.00	50
6 AWG	3x12	3 4	0.99 1.10	50
4 AWG	3x12	3 4	1.08 1.20	50
2 AWG	3x10	3 4	1.24 1.45	50
1 AWG	3x10	3 4	1.40 1.55	50
1/0 KCM	3x10	3 4	1.52 1.60	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
2/0 AWG	3x8	3 4	1.67 1.75	50
4/0 AWG	3x8	3 4	1.93 2.10	60
250 KCM	3x8	3 4	2.11 2.20	60
350 KCM	3x8	3 4	2.39 2.50	60
500 KCM	3x8	3 4	2.80 2.90	75

7. Manufacturer and Product: Okonite Co.; Type CLX MC-HL.

2.04 300-VOLT RATED CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 20, 16 AWG, Twisted, Shielded Pair Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57.

1. Outer Jacket: 35-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.26-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil PVC.
   d. Color Code: Pair conductors black and white.

5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.

2.05 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product: Belden; 7852A.

B. Type 31, Shielded Twisted Pair (UTP) Telephone and Data Cable, 600V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
   Suitable for high speed network applications including gigabit Ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
2. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and inner blue PVC jacket.
3. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
   Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
4. Outer Shield: Aluminum polyester tape shield with 100 percent coverage.
5. Outer Jacket: PVC.
6. Maximum Outer Diameter: 0.38-inch.
7. Manufacturer and Product: Belden; 7953A.

C. Type 33, Single-Twisted Pair, EIA RS-485 Cable (for MODBUS use):

1. Outer Shield:
   a. Aluminum Foil-Polyester Tape, 100 percent coverage.
   b. Tinned copper braid shield, 90 percent coverage.
2. Outer Jacket: Polyvinyl chloride, 0.035-inch nominal thickness.
3. Conductors:
   a. One pair 24 AWG, seven-strand tinned copper.
   b. Insulation: Polyethylene.
4. Drain: 24 AWG tinned copper.
5. Meets UL Style 2919, NEC/CEC/ (UL) CM.
6. Manufacturer and Product: Belden; 9841.

2.06 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.07 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or ZH-SCE.
      2) Brady, Type 3PS.

2. Heat Bond Marker:
   a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
   b. Self-laminating protective shield over text.
   c. Machine printed black text.
   d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
   a. Chemical-resistant white tag.
   b. Size: 1/2 inch by 2 inches.
   c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulink.
      3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. UL 486C.
   b. Plated steel, square wire springs.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
   a. Two piece compression type with set screw in brass barrel.
   b. Insulated by insulator cap screwed over brass barrel.
   c. Manufacturers:
      1) 3M Co.
      2) Thomas & Betts.
      3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy; Hydent.
      3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite.
      2) Burndy; Quiklug.
      3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
   a. Thomas & Betts; SHRINK-KON.
   b. Raychem; RNF-100 and ES-2000.

2.08 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.
3. Class 5 or 15 kV (as required), with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
4. Premolded splice shall be rejacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
   a. Elastimold.
   b. Cooper Industries.

B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
3. Class 5 or 15 kV (as required), with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal.
4. Manufacturers:
   a. Raychem.
   b. 3M Co.

C. Termination Kits:

1. Capable of terminating 5 or 15 kV (as required), single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
   a. Raychem.
   b. 3M Co.

D. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Manufacturer: Raychem.

E. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, 200A, 10,000A rms load-break and 600A, 40,000 rms nonload-break elbows as shown, having copper current-carrying parts in accordance with IEEE 386.
   a. BIL Rating Based on System Insulation Class:
      1) 15kV, 95kV BIL.
      2) 25kV, 125kV BIL.
2. Protective Caps: Class 200: and 600 amperes, with molded EPDM insulated body.
   a. BIL Rating Based on System Insulation Class:
      1) 15kV, 95kV BIL.
      2) 25kV, 125kV BIL.

3. Insulated Standoff Bushings: 200 and 600 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.
    a. BIL Rating Based on System Insulation Class:
        1) 15kV, 95kV BIL.
        2) 25kV, 125kV BIL.
4. Bushing Inserts: 200A, load-break 600A, nonload-break with EPDM rubber body and all-copper, current-carrying parts.
    a. BIL Rating Based on System Insulation Class:
        1) 15kV, 95kV BIL.
        2) 25kV, 125kV BIL.
5. Junctions: two-way, three-way, four-way, 200A, load-break, and 600A, nonload-break, having EPDM rubber body mounted on adjustable bracket. Type as shown on Drawings.
    a. BIL Rating Based on System Insulation Class:
        1) 15kV, 95kV BIL.
        2) 25kV, 125kV BIL.
6. Mounting Plates: Two-, three-, or four-way, ASTM A167 stainless steel, complete with universal mounting brackets, grounding lugs and two parking stands. As shown on Drawings.
7. Manufacturers:
    a. Cooper Industries.
    b. Elastimold.

F. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 5 or 15 kV (as required) of same material as conductor metal.
3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
    a. Burndy; Hydent.
    b. Thomas & Betts; Color-Keyed.
    c. ILSCO.
4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Thomas & Betts; Locktite.
    b. ILSCO.

2.09 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.10 BUSWAY

A. Low impedance, aluminum bus bar, with full neutral and internal ground bus.

B. Shall be weatherproof if rated located outdoors.

C. UL listed for support and spacing provided, meeting NFPA 70 requirements, and totally enclosed throughout its length.

D. Suitable for mounting in vertical (edgewise) or horizontal position without derating, and capable of withstanding short-circuit of 100,000 amperes.

2.11 MANUFACTURED WIRING SYSTEMS

A. System Rating:

1. 20 amperes load-carrying capacity each phase with final assemblies consisting of maximum of three-phase conductors.
2. Composition: Type MC cable with 90 degrees C insulation and stranded copper conductors.

B. Cable Configuration: Three, single-phase, five-wire circuit with standard color wire coding:

1. 208/120 Volt: Black, red, blue, white, green.
2. 480/277 Volt: Brown, orange, yellow, white, green.

C. Locking Mechanism: Latch/strike with voltage clearly marked on latch.

D. NFPA 262 listed for use in air handling plenums, listed to connect or disconnect under load, and manufactured in accordance with NFPA 70, Article No. 604.

2.12 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.13 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 8 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

J. Cable Tray Installation:

1. Install wire and cable parallel and straight in tray.
2. Bundle, in groups, wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.

3. Clamp cable bundles prior to making end termination connections.
4. Separate cables of different voltage rating in same cable tray with barriers.
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   a. Horizontal Runs: 20 feet.
   b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. Colors:
   a. Grounded Neutral: White.
   b. Phase A: Brown.
   c. Phase B: Orange.
   d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 01, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
   a. Under Infinite Access Floors: May install without bundling.
   b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   c. Maintain integrity of shielding of instrumentation cables.
   d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 CONDUCTORS ABOVE 600 VOLTS

A. Do not splice unless specifically indicated or approved by Engineer.

B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.

C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing, plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for riser pole and outdoor switchgear terminations.

G. Provide shield termination and grounding for terminations.

H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

J. Connections and Terminations:

1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.
2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
3. Insulate bus connections with heat shrinking tubing, tape, and sheets.

K. Where aluminum conductors are used, apply oxide-inhibiting compound at joints and terminations. Use compounds compatible with cable insulation and with components used for splicing and terminating.

L. Give 2 working days' notice to Engineer prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 5 kV and 15 kV cables throughout entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Wrap conductors of same circuit entering from separate conduit together as single cable.

C. Follow tape manufacturer's installation instructions.

D. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.07 BUSWAY

A. Install in strict accordance with manufacturer's recommendations and NFPA 70.

B. Maximum Support Spacing: 10 feet, unless noted otherwise.

3.08 SPECIAL CABLES

A. Type 30 and 31:

1. Install Category 6 telecommunications cabling and pathway system as detailed in TIA/EIA 568-B.1 and TIA/EIA 568-B.2.
2. Screw Terminals: Do not use, except where specifically indicated on Drawings.
3. Use approved insulation displacement connection (IDC) tool kit for copper cable terminations.
4. To maintain cable geometry do not untwist Category 5e or 6 UTP cables more than 1/2 inch from point of termination.
5. Provide service loop on each end of cable; 10 feet in SCADA cabinet, 12 inches in work area outlet for UTP.
6. Provide device to monitor cable pull tensions.
7. Do not exceed 25 pounds pull tension for four pair copper cables.
8. Do not chafe or damage outer jacket materials.
9. Use only lubricants approved by cable manufacturer.
10. Do not over cinch cables or crush cables.
11. For UTP cable, bend radius shall not be less than four times cable diameter per TIA/EIA-568-B.1-1.
12. Do not staple cables.
13. Tie wraps shall not be pulled so tight as to kink or crimp cable jackets.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data for the following:
      1) Exothermic weld connectors.
      2) Mechanical connectors.
      3) Compression connectors.
      4) Specialty tools.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL:
   a. Confirm conformance with UL standards.
   b. Supply with an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper-clad steel.

B. Diameter: Minimum 3/4 inch.

C. Length: 8 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers:
   a. Erico Products, Inc.
   b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers and Products:
   a. Burndy Corp.; Hyground Irreversible Compression.
   b. Thomas and Betts Co.
   c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.

D. Ground Plates:

1. Indoor Weld: Utilize low-smoke, low-emission process.
2. Manufacturers and Products:
   a. Erico Products, Inc.; Cadweld Type B161.
   b. Thermoweld.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast-iron riser ring and traffic cover marked “GROUND ROD”.

B. Manufacturers:

1. Christy Co.
2. Lightning and Grounding Systems, Inc.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding: In compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

G. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

D. Install to 8 feet below local frost depth.

3.05 GROUNDING WELLS

A. Install for ground rods located inside buildings, asphalt and paved areas, and where shown on Drawings.

B. Install riser ring and cover flush with surface.

C. Place 6 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

E. Ground Plates:

1. Indoor Weld: Utilize low-smoke, low-emission process.
2. Manufacturers and Products:
   a. Erico Products, Inc.; Cadweld Type B161.
   b. Thermoweld.

3.07 CAST-IN-PLACE CONCRETE STRUCTURE GROUNDING

A. Provide ground rods, buried ground ring, embedded ground ring, and embedded ground plates as shown on Drawings.

B. Bond electrical equipment and other metallic features to the grounding system as shown.

3.08 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.09 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions, unless otherwise shown on the Drawings.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.10 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.11 LIGHTNING PROTECTION SYSTEMS

A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.12 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
   b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   c. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   d. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
   e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
   f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
   h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
   j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   k. VE 1, Metallic Cable Tray Systems.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

6. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
7. UL:
    a. 1, Standard for Safety for Flexible Metal Conduit.
    b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
    c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
    d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
    e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
    f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
    g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
    h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
    i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
    j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
    k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
    l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
    m. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.
    n. 2420, Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
    o. 2515, Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
    a. Rigid galvanized steel conduit.
    b. Intermediate metal conduit.
    c. Electric metallic tubing.
    d. PVC Schedule 40 conduit.
    e. PVC Schedule 80 conduit.
    f. PVC tubing (Type EB) conduit.
    g. HDPE conduit.
    h. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
    i. Flexible metal, liquid-tight conduit.

j. Flexible, nonmetallic, liquid-tight conduit.
k. Flexible metal, nonliquid-tight conduit.
l. Conduit fittings.
m. Wireways.
n. Surface metal raceway.
o. Innerduct.
p. Device boxes for use in hazardous areas.
q. Junction and pull boxes used at or below grade.
r. Large junction and pull boxes.
s. Terminal junction boxes.

2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Telecommunications Pathway Cable Tray:
   a. Dimensional drawings, calculations, and descriptive information.
   b. NEMA load/span designation and how it was selected.
   c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
   d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
   e. Layout drawings and list of accessories being provided.
4. Cable Tray Systems:
   a. Dimensional drawings, calculations, and descriptive information.
   b. NEMA load/span designation and how it was selected.
   c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
   d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
   e. Layout drawings and list of accessories being provided.
5. Equipment and machinery proposed for bending metal conduit.
6. Method for bending PVC conduit less than 30 degrees.
7. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
8. Conduit Layout:
   a. Provide drawings for underground and concealed conduits including, but not limited to ductbanks, under floor slabs, concealed in floor slabs, and concealed in walls.
   b. Provide plan and section showing arrangement and location of conduit and duct bank required for:
      1) Low and medium voltage feeder and branch circuits.
      2) Instrumentation and control systems.
      3) Communications systems.
      4) Empty conduit for future use.
   c. Reproducible scale not greater than 1 inch equals 20 feet.

9. Steel pipe trench conduit installation plan to mitigate twisting and sagging of conduits in pipe trench.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Intermediate Metal Conduit (IMC):

1. Meet requirements of NEMA C80.6 and UL 1242.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

C. Electric Metallic Tubing (EMT):

1. Meet requirements of NEMA C80.3 and UL 797.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

E. PVC Schedule 80 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

F. PVC Tubing (Type EB):

1. Meet requirements of NEMA TC 6 and UL 651A.
2. UL listed for reinforced concrete encasement and 90 degrees C insulated conductors.

G. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1.
2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

H. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

I. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 1.
2. Material: Galvanized steel.

J. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Material: PVC core with fused flexible PVC jacket.
2. UL 1660 listed for:
   a. Dry Conditions: 80 degrees C insulated conductors.
   b. Wet Conditions: 60 degrees C insulated conductors.

3. Manufacturers and Products:
   a. Carlon; Carflex or X-Flex.
   b. T & B; Xtraflex LTC or EFC.

K. High Density Polyethylene (HDPE):

1. Meets requirements of:
   a. NEMA TC-7.
   b. UL 651B.
   c. NEC 353.
2. Wall Type: Schedule 40.

L. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth or corrugated HDPE as noted on Drawings.
3. Textile Manufacturer: Maxcell if noted on Drawings.

2.02 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
   b. Manufacturers and Products:
      1) Appleton; Series BU-I.
      2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
   a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
   b. Manufacturers and Products:
      1) Appleton; Series GIB.
      2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
   a. Material: Malleable iron with insulated throat with bonding screw.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) Appleton; Series HUB-B.
      2) O-Z/Gedney; Series CH.
      3) Meyers; ST Series.

5. Conduit Bodies:
   a. Sized as required by NFPA 70.
   b. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 35 threaded unilets.
      2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
      3) Killark; Duraloy 7 series.
      4) Thomas & Betts; Form 7 or Form 8.
   c. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
   a. Concrete tight, hot-dip galvanized malleable iron.
   b. Manufacturers and Products:
      1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
      2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type EYF, EYM, or ESU.
      2) Crouse-Hinds; Type EYS or EZS.
      3) Killark; Type EY or Type EYS.
9. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYD.
      2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
    a. Manufacturers and Products:
       1) Appleton; Type ECDB.
       2) Crouse-Hinds; ECD.
11. Expansion Fitting:
    a. Manufacturers and Products:
       1) Deflection/Expansion Movement:
          a) O-Z/Gedney; Type AXDX.
          b) Crouse-Hinds; Type XD.
       2) Expansion Movement Only:
          a) O-Z/Gedney; Type AX.
          b) Crouse-Hinds; Type XJ.
          c) Thomas & Betts; XJG-TB.
12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.

c. Manufacturers and Products:
   1) Appleton; CG-S.
   2) Crouse-Hinds; CGBS.

B. Electric Metallic Tubing:

1. Meet requirements of UL 514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Electro zinc-plated inside and out.
4. Raintight.
5. Coupling Manufacturers and Products:
   a. Appleton; ETP 6000S Series.
   b. Crouse-Hinds.
   c. Thomas & Betts.
6. Connector Manufacturers and Products:
   a. Appleton; ETP 7000S Series.
   b. Crouse-Hinds.
   c. Thomas & Betts.

C. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

D. Fiberglass Conduit:

1. Manufactured by same process as conduit.
2. Supplied by conduit manufacturer.

E. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure-sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
   a. Robroy Industries.
   b. Ocal.
8. Expansion Fitting:
   a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

F. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
   a. Thomas & Betts; Series 5331.
   b. O-Z/Gedney; Series 4Q.

G. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel or malleable iron.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

H. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
   a. Carlon; Type LT.
   b. O-Z/Gedney; Type 4Q-P.
   c. Thomas & Betts; Series 6300.

I. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
   a. Crouse-Hinds; Type ECGJH or Type ECLK.
   b. Appleton; EXGJH or EXLK.

J. Watertight Entrance Seal Device:

1. New Construction:
   a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
   b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.

2. Cored-Hole Application:
   a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
   b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron or cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS or Type FD.
   b. Appleton; Type FS or Type FD.
   c. Killark.
6. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA or Type EAJ.
   b. Appleton; Type GR.

C. Cast Aluminum:

1. Material:
   a. Box: Cast, copper-free aluminum.
   b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS-SA or Type FD-SA.
   b. Appleton; Type FS or Type FD.
   c. Killark.
5. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA-SA.
   b. Appleton; Type GR.

D. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
   a. Exterior Surfaces: 40-mil PVC.
   b. Interior Surfaces: 2-mil urethane.

4. Manufacturers:
   a. Robroy Industries.
   b. Ocal.

E. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron or ferrous metal, hot dip galvanized finish, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged screws.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
   a. Crouse-Hinds; Series W.
   b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type: O-Z/Gedney; Series YW.
8. Manufacturers and Products, Recessed Type:
   a. Crouse-Hinds; Type WJBF.
   b. O-Z/Gedney; Series YR.

E. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250, Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
3. Cover: Hinged or Nonhinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
   a. Crouse-Hinds; Type EJB.
   b. Appleton; Type AJBEW.

F. Large Stainless Steel Box:

1. NEMA 250 Type 4X
2. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
   a. Hoffman Engineering Co.
   b. Robroy Industries.
   c. Wiegman.

G. Large Steel Box:

1. NEMA 250 Type 1,3R, or 12 (as specified in Section 26 05 04, Basic Electrical Materials and Methods in Article Enclosures).
2. Box: 14-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Owner.
3. Cover: Hinged with clamp screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
   a. Hoffman Engineering Co.
   b. Robroy Industries.
   c. Wiegman.

H. Large Nonmetallic Box:

1. NEMA 250 Type 4X.
2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
3. Cover: Hinged with clamps.

4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Conduit hubs and mounting lugs.
6. Manufacturers and Products:
   a. Crouse-Hinds; Type NJB.
   b. Carlon; Series N, C, or H.
   c. Robroy Industries.

I. Concrete Box, Traffic Areas:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading with screw down.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Manufacturers and Products:
   a. Christy, Concrete Products, Inc.; B1017BOX.
   b. Utility Vault Co.; 3030 SB.

J. Below Grade Junction Box, Incidental Traffic

Load Rating: ANSI/SCTE, Tier 22.

1. Size: As shown on Drawings or indicated in Standard Details.
   a. Minimum Size: 48 inches wide by 30 inches in length by 24 inches deep.
2. Material: Polymer Concrete
3. Lid: ANSI/SCTE, Tier 22 Polymer Concrete Lid.
   a. Stainless steel hex head locking bolt.
      Label: “ELECTRICAL” or “COMMUNICATIONS” as applicable.
   b. Lifting slot or lifting bolt to aid in removing lid.
4. Straight wall side.
5. Bottom:
   a. Solid concrete.
   b. Open with prefabricated bottom is acceptable.
6. Box shall be suitable for cutting out openings in the side for conduit to enter without sacrificing loading.
7. Manufacturer; Model:
   a. Hubbel; Quazite PG3048BA24.
   b. “Or-equal.”

2.05 TELEPHONE AND DATA OUTLET

A. Provide outlet boxes and cover plates meeting requirements of TIA 569B.

2.06 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 25 percent, minimum.

2.07 SURFACE METAL RACEWAY

A. General:

1. Meet requirements of UL 5.
2. Material: Two-piece, code-gauge steel.
3. Finish: Factory applied rust inhibiting primer and gray semi-gloss finish suitable for field painting.
4. Configuration: Single, 1-17/32-inch by 2-3/4-inch section, unless otherwise indicated.

B. Fittings and Accessories:

1. Wire clips at 30 inches on center.
2. Couplings, cover clips, supporting clips, ground clamps, and elbows as required; to comply with manufacturer's recommendations.

C. Outlets:

1. Provide bracket or device covers as required to support wiring devices indicated.
2. Wiring Devices and Device Plates: In accordance with Section 26 27 26, Wiring Devices.
3. Manufacturers:
   a. The Wiremold Co.
   b. Walker.

2.08 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Removable, screw type.

D. NEMA 250 type base on location (as specified in Section 26 05 04, Basic Electrical Materials and Methods, in Article Enclosures) or as noted on Drawings.

E. Finish:

1. Rust inhibiting phosphatizing primer and gray baked enamel.
2. Type 316 stainless steel where noted on Drawings.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. B-line.
2. Hoffman.
3. Square D.

2.09 NONMETALLIC WIREWAY

A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.

B. Type: Fiberglass-enclosed, with removable cover.

C. Captivated, corrosion-resistant cover screws.

D. Oil-resistant gaskets.

E. Meet UL cold impact test to minus 35 degrees C.

F. Manufacturer: Hoffman.

2.10 CABLE TRAYS

A. Meet requirements of NEMA VE 1.

B. Type: As indicated, of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6 or Steel, hot-dip galvanized after welding to ASTM A123/A123M finish as noted on Drawings.

D. Width and Depth Dimensions: As noted on Drawings.

E. Bending Radius: 12 inches, unless noted otherwise.

F. Cover: As noted on Drawings.

G. Barrier Strip: Vertical, solid type, with horizontal fittings and strip clamps.

H. Fittings of same material as cross-sectional tray area and hardware of same material as cable tray.

I. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

J. Provide next higher NEMA VE 1 class designation than required for support of designed span length.

K. Design Loads: Use working load adequate for actual cable installed plus 20 percent additional weight allowance for future cables plus 200-pound concentrated static load applied between side rails at midspan, with safety factor of 1.5 in accordance with NEMA VE 1, Table 3-1.

L. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation.

M. Furnish cable tray with no sharp edges, burrs, or weld projections.

N. Warning Signs: 1-1/2-inch high black lettering on yellow background with legend, “WARNING, NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL.”

O. Manufacturers:

1. B-Line.
2. Square-D.
3. Legrand; PW.
4. T. J. Cope, Inc.

2.11 TELECOMMUNICATIONS PATHWAY CABLE TRAY

A. Meet requirements of NEMA VE 1.

B. Type: Ladder, of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6 finish.

D. Dimensions: Unless otherwise indicated, 18 inches wide, with 4-inch NEMA nominal inside fill depth and fittings with 24-inch bending radius.

E. Fittings of same material as cross-sectional tray area and hardware of same material as cable tray. Include dropouts for cable exits from bottom of tray as required.

F. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

G. Warning Signs: 1-1/2-inch (40-mm) high black lettering on yellow background with legend, “WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL.”

H. Design Loads: 15 pounds per linear foot with less than 1-inch deflection, and maximum 50 pounds per linear foot, when supported on 12-foot centers.

I. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation, with bonding jumper.

J. Furnish cable tray with no sharp edges, burrs, or weld projections.

K. Manufacturers:

1. B-Line Systems, Inc.
2. Square-D.
3. Legrand; PW.

2.12 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6-inch or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

D. Drainage:

1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe. Provide no drainage outlet.

E. Raceway Entrances:

1. Provide on all four sides.
2. Provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:

1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
2. Location:
   a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
   b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:

1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
2. Wall Attachment:
   a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
   b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
   c. Arrange in order that spare raceway ends are clear for future cable installation.

H. Manhole Frames and Covers:

1. Material: Machined cast iron.
2. Diameter: 36-1/2 inch.
3. Cover Type: Indented, solid top design, with two drop handles each.
4. Cover Loading: AASHTO HS-20.
5. Covers shall bolt down to frame with stainless steel pentahead bolt.
6. Provide bottom gasket to prevent water egress into enclosure.
7. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
   a. Above 600 Volts: ELECTRIC HV.
   b. 600 Volts and Below: ELECTRIC LV.
   c. TELEPHONE.

I. Handhole Frames and Covers:

1. Handholes with Incidental Traffic (parking lots, sidewalks, grass):
   a. Material: Steel, hot-dipped galvanized.
   b. Cover Type: Solid, hinged, torsion spring, of nonskid design.
   c. Cover Loading: AASHTO H-20.
   d. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
      1) 600 Volts and Below: ELECTRIC LV.
      2) COMMUNICATIONS.

2. Handholes in Roads:
   a. Material: Machined cast iron.
   b. Diameter: 30-inch.
   c. Cover Type: Indented, solid top design, with two drop handles each.
   d. Cover Loading: AASHTO HS-20.
   e. Covers shall bolt down to frame with stainless steel pentahead bolt.
   f. Provide bottom gasket to prevent water egress into enclosure.
   g. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
      1) 600 Volts and Below: ELECTRIC LV.
      2) COMMUNICATIONS.

J. Hardware: Steel, hot-dip galvanized.

K. Furnish knockout for ground rod in each handhole and manhole.

L. Manufacturers:

1. Oldcastle Precast.
2. Harper Precast.

2.13 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
   a. Nonmetallic, interlocking, for multiple conduit sizes.
   b. Suitable for all types of conduit.
   c. Manufacturers:
      1) Underground Device, Inc.
      2) Carlon.
2. Template Type:
   a. Nonmetallic, custom made one-piece spacers.
   b. Suitable for all types of conduit.
   c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
   d. Conduit openings cut 1 inch larger than conduit outside diameter.
   e. Additional openings for stake-down, rebar, and concrete flow through as required.
   f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, nonferrous metal.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Marking Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 3 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
   a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
   b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
   c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.

C. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

D. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
   a. Raychem.
   b. 3M.

E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
2. Conduit is sized per the NEC.
3. Conduit is of the type specified in Contract Documents.
4. Conduit is supported as specified in Contract Documents.

B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.

6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed: Rigid galvanized steel.

C. Interior, Exposed:

1. Rigid galvanized steel.
2. Electric metallic tubing for ceiling portion of lighting circuits.

D. Interior, Concealed (Not Embedded in Concrete): Electric metallic tubing.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

F. Direct Earth Burial:

1. PVC Schedule 40.
2. HDPE Schedule 40.

G. Concrete-Encased Ductbank:

1. PVC Schedule 40.
2. PVC tubing (Type EB).
3. HDPE Schedule 40.

H. Under Slabs-On-Grade: PVC Schedule 40.

I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.

J. Under Equipment Mounting Pads: PVC Schedule 40 conduit.

K. Exterior Light Pole Foundations: PVC Schedule 40 conduit.

L. Corrosive Areas:

1. PVC-coated rigid galvanized steel.
2. PVC Schedule 80.

M. Hazardous Gas Areas: Rigid galvanized steel.

3.05 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet Areas: Flexible or flexible metal liquid-tight.
4. Corrosive Areas: Flexible, nonmetallic liquid-tight.
5. Dry Areas: Flexible, metallic liquid-tight.
6. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; enough to allow movement or adjustment of equipment.

3.06 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.

D. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
   a. Provide a watertight seal.
   b. Without Concrete Encasement: Install watertight entrance seal device on each side.
   c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
   d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
   e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
   a. Penetrate equipment in area established by manufacturer.
   b. Terminate conduit with flexible metal nonmetallic conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
   c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Corrosive-Sensitive Areas:
   a. Seal conduit passing through areas with corrosive gasses.
   b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
   c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
   a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
   b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
   a. Metallic Raceways: Provide insulated grounding bushings.
   b. Nonmetallic Raceways: Provide bell ends flush with wall.
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 8 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 25 percent extra space for future conduit.

C. Application/Type of Conduit Strap:

1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
4. Steelwork: Machine screws.
5. Location/Type of Hardware:
   a. Dry, Noncorrosive Areas: Galvanized.
   b. Wet, Noncorrosive Areas: Stainless steel.
   c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.08 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends. Field bending with heat source is acceptable if conduit cross sectional circular shape is maintained without sagging, loosing symmetry, or conduit integrity is not compromised.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.13 CABLE TRAYS

A. Install in accordance with NEMA VE 1, section Application Information.

B. Install accessories as necessary for complete system.

C. Install in order that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for horizontal cable tray.

F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Provide expansion joints in accordance with NEMA VE 1 for 50 degrees F maximum temperature variation.

H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 25 feet and within a cumulative maximum of 1/2 inch.

I. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

J. Install without exposed raw edges.

K. Maintain 12-inch vertical separation between multi-tiered trays having a common support, and at crossover locations.

L. Provide bonding jumper at each expansion joint and adjustable connection.

M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.14 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized Intermediate Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.15 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Concrete Encasement:

1. As specified in Section 03 30 00, Cast-in-Place Concrete.
2. Concrete Color: Red.

K. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill.
2. Do not backfill until inspected by Engineer.

3.16 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.17 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
   a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
   c. Do not straddle CMU block or other construction joints.
2. Light Switch:
   a. 48 inches above floor.
   b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
   a. 15 inches above floor.
   b. 6 inches above counter tops.
   c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
   a. General Interior Areas: 15 inches above floor.
   b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
   c. Industrial Areas, Workshops: 48 inches above floor.
   d. Outdoor Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: 48 inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.18 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.19 TELEPHONE AND DATA OUTLET

A. Provide empty 4-11/16-inch square, deep outlet box.

B. Provide blank single gang raised device cover if cables are not installed.

3.20 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.21 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.22 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination or Raceway Schedule designation.
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide noncorrosive wire for attachment.

B. Marking Tape: Install approximately 18 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.
2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.23 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Code of Federal Regulations (CFR): 10 CFR Part 431, DOE 2016 efficiency.
2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
3. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. UL:
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.
5. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Test Report: Sound test certification for dry type power transformers (0 volt to 600 volt, primary).

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with aluminum windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed DOE 2016 efficiency requirements.

E. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

F. Overload Capability: Short-term overload per IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:

1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

I. Manufacturers:

1. Eaton.
2. ABB/General Electric Co.
3. Schneider Electric/Square D Co.

2.02 MINI-POWER CENTER (MPC)

A. General: Transformer, primary, and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 3R unless note otherwise on Drawings.

B. Transformer:

1. Insulation Class and Temperature Rise: Manufacturer's standard.
2. Efficiency: Manufacturer's standard (DOE 2016 efficiency).
3. Core and Coil: Encapsulated.
4. Full capacity, 5 percent voltage taps, two below normal voltage.
5. Primary Voltage: As noted on Drawings.
6. Secondary Voltage: As noted on Drawings.

C. Panelboard: Full, UL 489, short-circuit current rated.

1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
2. Number and Breaker Ampere Ratings: Refer to panel schedule on Drawings.

2.03 GENERAL PURPOSE TRANSFORMER

A. Low voltage transformers shall be general purpose type, unless specifically identified as K-Rated, or shielded, isolation transformer on Drawings.

B. Insulation Class and Temperature Rise: Manufacturer's standard.

C. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

D. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

E. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Two 5 percent, full capacity, below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: Two 5 percent, full capacity, below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

F. Impedance: 1.9 percent minimum on units 75 kVA and larger.

2.04 K-RATED TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard. 115 degrees C temperature rise.

B. Core and Coil: Sized and configured to reduce overheating caused by harmonic components.

C. Enclosure: NEMA 250, Type 2 (with weathershield for NEMA 3R rating when located in wet area).

D. Voltage Taps: Six 2.5 percent, full capacity; two above and four below normal voltage rating.

E. K Factor: As shown on Drawings.

F. Neutral Bus and Terminal: 200 percent of rated current.

G. Electrostatic shield.

2.05 SHIELDED, ISOLATION TRANSFORMER

A. Enclosure: NEMA 250, Type 2.

B. Primary Winding Taps: Six 2-1/2 percent, full capacity; two above and four below rated voltage.

C. Insulation Class and Temperature Rise: Manufacturer's standard.

D. Isolation and Noise Suppression:

1. Electrostatic Shield (Including Core and Coils): One-foil type, located between primary and secondary windings.
2. Ground Lead: From each shield to unit enclosure.
3. Common Mode Attenuation: 120 dB.

4. Transverse Mode Attenuation: 20 dB.
5. Impedance: 4.3 percent, maximum.
6. Reactance: Minimum 3 percent; maximum 4.2 percent.
7. Regulation, No-Load to Full-Load: Plus or minus 1.2 percent.
8. Output Distortion: None added.
9. Fused Transient Suppression:
    a. Peak Transient Current: 30,000 amps (8 by 20 microsecond wave).
    b. Maximum Clamping Voltage: 360 volts at 1,000 amps.
    c. Pulse Transient Energy: 420 joules.
    d. Response Time: Less than 25 nano-seconds.
10. Primary Surge Protection:
    a. Peak Transient Current: 40,000 amps.
    b. 10-Microsecond Rise Time Volts: 2.9 kV.
11. Magnetic field strength around transformer shall be less than 0.1 gauss at 1-1/2 feet.
12. Thermal Switches:
    a. Two, located in center cove “hot spot” to provide two-stage (high and high-high alarm) thermal sensing.
    b. Rating: 5 amps, 120 volts, with one normally open and one normally closed contact.
    c. Visual indicator to signal blown transient suppressor fuse.
13. Units larger than 5 kVA suitable for use with 75 degrees C wire at NEC, 75 degrees C ampacity.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer’s instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA.

F. Isolation Transformer: Ground isolation shields to unit enclosure with conductor of same material, and same size minimum, as shield ground lead provided with unit.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. KS 1, Enclosed Switches.
   d. PB 1, Panelboards.
   e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. UL:
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Ground-Fault Circuit-Interrupters.
   h. 1699, Standard for Arc-Fault Circuit-Interrupters.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.

c. Space for future protective devices.
d. Voltage, frequency, and phase ratings.
e. Enclosure type.
f. Bus and terminal bar configurations and current ratings.
g. Provisions for circuit terminations with wire range.
h. Short circuit current rating of assembled panelboard at system voltage.
i. Features, characteristics, ratings, and factory settings of auxiliary components.
j. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

1.04 EXTRA MATERIALS

A. Extra Materials: Furnish, tag, and box for shipment and storage the following material:

Item	Quantity
Touch-up paint for panelboards	One half-pint container

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton.
2. Schneider Electric/Square D Co.
3. ABB/General Electric Co.
4. Siemens.

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 14 13, Switchboards; Section 26 24 19, Low-Voltage Motor Control; and Section 26 23 00, Low-Voltage Switchgear, if those specifications are included in the Contract Documents.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this section, including panelboards installed in other equipment specified. Other sections in Contract may include Section 26 24 19, Low-Voltage Motor Control; Section 26 14 13, Switchboards; Section 26 23 00, Low-Voltage Switchgear; and Section 26 32 13.13, Diesel Engine Generator Set.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Provide panelboard assemblies, including protective devices, suitable for use with 75 degrees C or greater wire insulation systems at NFPA 70, 75 degrees C conductor ampacity, and in accordance with UL 486E.
2. Lugs for termination of conductors shall comply with Section 26 05 05, Conductors.
3. Lugs for termination of copper feeder phase and neutral conductors shall be replaceable, bolted mechanical or crimp compression type only.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous” or “100 percent”, selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the indicated SCCR.

F. Series-Connected Short Circuit Current Ratings: Panelboards shall be fully rated; application of series-connected device ratings is unacceptable.

2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overcurrent Device Mounting and Arrangement: Design panelboards to accommodate device installation and replacement without disturbing adjacent devices and without removing main bus.

B. Overcurrent Protective Devices: In accordance with NEMA KS 1, UL 98, and UL 489. Protective devices shall be adapted to panelboard installation.

C. Provisions for Future Overcurrent Device:

1. Provide space, mountings and bus connections such that like device may be installed without additional hardware.
2. Panel openings shall be closed with individual removable cover for each provision for future device.
3. Unless otherwise indicated, “spaces” in panelboards shall be fully equipped provision for future like devices.
4. Provisions for future devices shall be suitable devices rated no less than 60 amperes.

D. Protective Device Locking: Furnish provisions for handle padlocking for main, subfeed, and branch devices where indicated.

E. Branch Protective Devices:

1. Provide Wire Lug Load Connections: Mechanical or crimp compression type removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
2. Provide a nameplate for each circuit, blanks for spares.

2.04 CIRCUIT BREAKERS

A. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle. Circuit breakers shall comply with Section 26 05 04, Basic Electrical Materials and Methods.

B. Bus Connection: Bolt-on circuit breakers in all panelboards.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.

D. Unacceptable Substitution:

1. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
2. Do not use tandem or dual circuit breakers in normal single-pole spaces.

E. Specialty Breakers: Where indicated, provide breakers with the following features:

1. Ground Fault Circuit Interrupter (GFCI): Rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel). Ground fault sensor shall be rated same as circuit breaker. Breaker shall include push-to-test and reset buttons.
2. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
3. Arc Fault Circuit Interrupter (AFCI): Where indicated, equip breaker with arc fault sensor to detect and trip the circuit breakers when an arcing fault occurs (UL 1699 listed).
4. Heating and Air Conditioning Rated (HACR): Where indicated, provide breaker UL listed for the protection of such equipment.

F. Solid State Trip Units: Where indicated, equip breakers with solid state trip units.

1. Long (Time) Short (Time) Instantaneous (LSI): Electronic trip unit with fixed long-time trip, adjustable short-time trip and delay, and adjustable instantaneous trip settings.
2. Long (Time) Short (Time) Instantaneous Ground (Fault) (LSIG): Electronic trip unit as above and with adjustable ground fault trip and delay settings.

G. Fused Switch:

1. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
2. UL 98 listed for use and location of installation and comply with NEMA KS 1.
3. Fuse Provisions:
   a. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
   b. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
4. Interlock fuse cover and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

5. Fuses: Provide for each ungrounded circuit conductor as specified in Section 26 05 04, Basic Electrical Material and Methods.
6. Only provide fused switch panelboards when specifically noted. Standard panelboards will be circuit breaker type.

2.05 ENCLOSURES

A. General:

1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Type 1, Type 3R, and Type 3S material code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Provide surface-mount panelboard from trim with same dimensions as box front.

B. Finish: Rust inhibitor prime followed by manufacturer's standard gray baked enamel or lacquer.

C. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Secure front trim to box with concealed trim clamps.
2. Overlap flush panelboards front trims with box nominal 3/4 inch on all sides.
3. Provide door in panelboard front trim, with concealed hinges, to access protective device operating handles.
4. Provide multi-point latching for doors over 30 inches in height.
5. Door Lock: Secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
7. Hinged Front Cover (Door in Door): Entire front trim hinged to surface box with standard door within hinged trim cover when noted on Drawings.

D. Multi-Section Panelboards: Where more than one section is required, provide multiple panelboard sections with separate fronts.

1. Sections shall be suitable for individual mounting to be field interconnected to form a single electrical unit.
2. Recessed-mount sections of the same panel shall all have the same size tubs and flush covers.
3. Surface-mount multi-section panelboards may be comprised of sections of unequal heights.

4. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard. Unless otherwise indicated, provide feed-through lugs on each section but last.
5. Provide neutral and ground terminal bars in each section.

2.06 BUSSING AND TERMINAL BARS

A. Bus:

1. Material: Copper. Full sized throughout length. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

B. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, and others.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

C. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.
3. Termination Points: Bolted crimp compression lugs for conductors 6 AWG and larger.
4. Oversize Neutral: Provide oversized neutral terminal bus as indicated.

D. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.07 SPECIAL FEATURES

A. General: Where indicated on Drawings or schedules, provide special features as specified.

B. Service Equipment Approval: Listed for use as service equipment for panelboards having service disconnecting means.

C. Extra Gutter Space: Dimensions and arrangement indicated.

D. Subfeed: Protective device or lugs indicated, with additional terminals on neutral and ground bus to accommodate feeder.

E. Feed-Through Lugs: At opposite end of phase bus from mains, with additional terminals on neutral and ground buses, sized to accommodate feeders indicated.

F. Double Main Lugs: Furnish additional terminals on neutral and ground buses, sized to accommodate feeders indicated.

G. Surge Arresters:

1. Comply with Section 26 43 00, Surge Protection Devices.
2. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer's recommendation.
3. Provide factory mounting within panelboard utilizing UL-recognized mounting device.

H. Fire Alarm Circuits: Identify all branch circuits feeding fire detection and alarm panels and equipment with a red, engraved to white core, plastic nameplate attached to the individual branch circuit breakers. Engrave nameplates with "FIRE ALARM CIRCUIT".

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1, and manufacturers' written installation instructions.

B. Install securely, plumb, in-line, and square with walls.

C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.

G. Mount flush panels uniformly flush with wall finish.

H. Provide typewritten circuit directory for each panelboard.

I. In addition to conduit or nipples otherwise required for feeder and branch circuit wiring between multi-section panelboard sections, provide nipples for branch circuits two trade sizes larger than required for installed branch circuit wires or an empty 2-inch nipple, or a 1-1/4-inch trade size conduit if tubs are more than 24 inches apart.

J. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub four 1-inch empty conduits into raised floor space or to accessible location below slab above grade.

K. Provide engraved identification for each protective device.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. Federal Specifications (FS):
   a. W-C-596G, General Specification for Connector, Electrical, Power.
   b. W-S-896F, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
   a. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
   b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits.
4. National Electrical Contractors Association (NECA): 1, Standard Practice of Good Workmanship in Electrical Contracting.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. FB 11, Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
   c. WD 1, General Color Requirements for Wiring Devices.
   d. WD 6, Wiring Devices – Dimensional Specifications.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL:
   a. 498, Standard for Safety for Attachment Plugs and Receptacles.
   b. 508, Standard for Safety for Industrial Control Equipment.
   c. 943, Standard for Safety for Ground-Fault Circuit-Interrupters.
   d. 1010, Standard for Safety for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
   e. 1436, Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices.
   f. 1449, Standard for Safety for Surge Protective Devices (SPD).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data for wiring devices.

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F.
2. Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
5. Rating: 20 amps, 120/277 volts.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Special Features: Provide the following features in comparable devices where indicated:
   a. Three-way and four-way.
   b. Tamper resistant.
   c. Key operated with key.
   d. Locator, illuminated operator.
   e. Pilot, red illuminated operator.
   f. Rectangular (decorator) face.
   g. Three-position, maintained contact, center off.
8. Manufacturers and Products, Industrial Grade:
   a. Cooper Arrow Hart; AH1220 Series.
   b. Bryant; 4901 Series.
   c. Hubbell; 1221 Series.
   d. Leviton; 1221 Series.
9. Manufacturers and Products, Commercial Grade:
   a. Cooper Arrow Hart; CSB120 Series.
   b. Bryant; CSB120 Series.
   c. Hubbell; CSB120 Series.
   d. Leviton; CSB1-20 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. UL 508 listed.
3. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
4. Minimum General Purpose Rating: 30 amperes, 600V ac.

5. Minimum Motor Ratings:
   a. 2 horsepower for 120V ac, single-phase, two-pole.
   b. 3 horsepower for 240V ac, single-phase, two-pole.
   c. 15 horsepower for 480V ac, three-phase, three-pole.
6. Screw-type terminal.
7. Manufacturers and Products:
   a. Cooper Arrow Hart.
   b. Hubbell Bryant: HBL78 Series.
   c. Leviton.

2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finder grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Special Features: Provide the following features in comparable devices where indicated:
   a. Listed weather-resistant per NEC 406.8 for installation in damp or wet locations.
   b. Listed tamper-resistant per NEC 406.11 for installation in dwelling units.
   c. Isolated ground.
   d. Illuminated.
   e. Smooth face
   f. Rectangular (decorator) smooth face.
9. Industrial Grade Manufacturers and Products:
   a. Cooper Arrow Hart; 5362 Series.
   b. Hubbell Bryant; HBL5362 Series.
   c. Leviton; 5362 Series.
10. Commercial Grade Manufacturers and Products:
   a. Cooper Arrow Hart; CR20 Series.
   b. Hubbell Bryant; CRF20 Series.
   c. Leviton; BR20 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant per NEC 406.8 for installation in damp or wet locations.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
   a. Hubbell Bryant; GFTR20 WRVGF20 Series.
   b. Leviton; 7899 Series.

C. Receptacle, Corrosion-Resistant:

1. Meet requirements of general-purpose receptacle.
2. Nickel coated metal parts.
3. Manufacturers and Products:
   a. Hubbell Bryant; HBL53CM Series.
   b. Leviton; 53CM-62 Series.
   c. Cooper Arrow Hart; 5362CR Series.

D. Receptacle, Special-Purpose:

1. Rating and number of poles as indicated or required for anticipated purpose.
2. Provide one matching plug with cord-grip features for each special-purpose receptacle.

E. Receptacle, USB Charger:

1. Meet requirements of general-purpose receptacle.
2. Duplex receptacle with two-port USB charger.
3. Listed UL 498 and UL 1310.
4. Commercial Grade Manufacturers and Products:
   a. Leviton; T5832 Series.
   b. Cooper; TR7746 Series.
   c. Hubbell; USB20X2 Series.

2.03 TELEPHONE AND DATA JACK

A. Compatible with Category 6 cable, and backwards compatible with Category 5 and Category 5e.

1. High-impact thermoplastic body.
2. Termination Type:
   a. IDC with pair separation towers.
   b. Compatible with 110-style termination tool.
3. Snap-on cap to secure connections.

4. Listed UL 1863.
5. Manufacturers and Products:
    a. Hubbell; HXJ6 Series.
    b. Leviton; 61110 Series.

2.04 HAZARDOUS (CLASSIFIED) LOCATION DEVICES

A. Wiring devices for hazardous (classified) locations shall comply with NEMA FB 11 and UL 1010.

B. Switch:

1. Industrial grade, totally enclosed, ac type, with tumbler switch.
2. Capable of three-way or four-way operation where indicated on Drawings.
3. Rating: 20 amps at 120/277 volts.
4. Material: Cast aluminum back body and cover.
5. Hazardous Area Ratings: NEMA 7D suitable for Class I, Group C and Group D; Class 2, Groups E, F and G; and Class 3 locations.
6. Manufacturers and Products:
    a. Killark: XS Series.
    b. Appleton: EDS Series.

C. Switch, Motor Rated:

1. Enclosed manual motor starter-type, three-pole, non-reversing without overloads.
2. Minimum Motor Rating: 10 horsepower, 480V ac, three-phase, three-pole.
3. Enclosure: NEMA 250, Type 7.
4. Operator: External handle with padlocking provisions.
5. Manufacturer and Product: Eaton, Type B101.

D. Receptacles, General:

1. Contain integral switch which must be closed to energize circuit.
2. Design shall permit only an approved plug to be energized.
    a. Actuation of switch shall require plug be inserted and rotated approximately 45 degrees.
    b. Plug shall lock into this position preventing unintended disengagement.
    c. To remove, plug shall be turned opposite direction as engagement and pulled straight out.

E. General Purpose Receptacle, Explosion Proof, 125 Volts, 20 Amps:

1. Dead front, interlocked, circuit breaking.
2. Receptacle Cover: Spring loaded closes when plug is removed.

3. Enclosure: Corrosion-resistant, aluminum alloy with less than 0.4 percent copper.
4. Finish: Electrostatically applied and baked powder epoxy/polyester.
5. External Hardware: Type 316 stainless steel.
6. Switch Chamber: Factory sealed to contain switch's arcing components.
7. Hazardous Area Ratings: Suitable for Class I, Division 2 NEMA 7BCD, 9FG.
8. Provide matching plug with each receptacle.
9. Manufacturers and Products:
   a. Cooper Crouse-Hinds; Ark Guard 2, Series ENR.
   b. EGS/Appleton Electric; U-Line.
   c. Killark, a division of Hubbell Inc.; UGR/UGP.

F. Ground Fault Circuit Interrupter (GFCI), Explosion-Proof:

1. Meet requirements of general-purpose receptacle, except as otherwise indicated.
2. Hazardous Area Ratings: NEMA 7D suitable for Class I, Group C and Group D, Class 2, Groups F and G, and locations.
3. Provide matching plug with each receptacle.
4. Manufacturers and Products:
   a. Killark; Acceptor Series UGFI.
   b. Appleton; EFSXXX-2023GFI.

2.05 MULTIOUTLET SURFACE RACEWAY SYSTEM

A. Three-wire grounding simplex receptacles, spaced on 6-inch centers with insulated grounding conductor to each receptacle.

1. Color: Gray with ivory receptacles.
2. Receptacles shall meet applicable requirements of Paragraph General Purpose Receptacle.
3. Manufacturer and Product: The Wiremold Co.; Plugmold Type 2000.

2.06 DEVICE PLATES

A. Sectional type plate not permitted.

B. Nylon:

1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
2. Color: To match associated wiring device.
3. Mounting Screw: Oval-head metal, color matched to plate.

C. Stainless Steel:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:

1. Material: Malleable ferrous metal, with gaskets.
2. Screw: Oval-head stainless steel.

E. Sheet Steel:

1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.
3. Manufacturers:
   a. Appleton.
   b. Crouse-Hinds.

F. Weatherproof:

1. Receptacle, Weatherproof Type 1:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
   b. Mounting Screw and Cap Spring: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; Type WLRD-1.
      2) Appleton; Type FSK-WRD.
2. Receptacle, Weatherproof Type 2:
   a. UL listed for wet location while in use.
   b. Die cast metal cover.
   c. Locking type.
   d. Manufacturer and Product: TayMac; Type Multi-Mac.
3. Switch:
   a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; DS-181 or DS-185.
      2) Appleton; FSK-1VTS or FSK-1VS.

G. Raised Sheet Steel: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel box.

2.07 OCCUPANCY SENSOR, WALL SWITCH

A. Description:

1. Passive-infrared type, 120/277-volt, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 square feet (84 square meters).
2. Provide dual switch unit where indicated.
3. Color: Manufacturer's standard white.

B. Manufacturers and Products:

1. Hubbell; WS1277.
2. Leviton; ODS 10-ID.
3. Pass & Seymour; WS3000.
4. Watt Stopper (The); WS-200.

2.08 FINISHES

A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below.

B. Wiring Device Connected to Normal Power System:

1. Office Areas: White.
2. Other Areas: Gray.

C. Wiring Device Connected to Standby Power System: Red.

D. Special purpose and hazardous location devices may be manufacturer's standard color (black).

E. Corrosion-resistant receptacle may be manufacturer's standard color (yellow).

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Comply with NECA 1.

B. Coordination with Other Trades:

1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.

2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
4. Install wiring device after wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction or that show signs they 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 last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.
5. Use torque screwdriver when a torque is recommended or required by manufacturer.
6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
7. Tighten unused terminal screws on device.
8. Device Plates:
   a. Do not use oversized or extra deep plate.
   b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.02 SWITCH INSTALLATION

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position such that toggle is in up position when ON.
3. Install within sight of motor when used as disconnect switch.

C. Occupancy Sensor, Wall Switch: Install in accordance with manufacturer's instructions.

3.03 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot up, except where horizontal mounting is shown, in which case install with neutral slot up.
2. Weatherproof Receptacle:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
3. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.
4. Special-Purpose Receptacle: Install in accordance with manufacturer's instructions.

B. Multioutlet Surface Raceway System:

1. Install in accordance with manufacturer's instructions.
2. Wire alternate outlets to each circuit where two-circuit, three-wire supply is shown.

3.04 DEVICE PLATE INSTALLATION

A. Securely fasten to wiring device; ensure tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plate has no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Label with designated title.

F. Type (Exterior):

1. Switch: Weatherproof.
2. Receptacle in Damp Location: Weatherproof Type 1.
3. Receptacle in Wet Location: Weatherproof Type 2.

G. Type (Interior):

1. Office Areas: Stainless steel.
2. Flush Mounted Box: Stainless steel.
3. Surface Mounted, Metal Box:
   a. General Purpose Areas (Dry, non-industrial): Sheet steel.
   b. Other Areas: Cast metal.
4. Surface Mounted, Aluminum Box:
   a. General Purpose Areas: Stamped.
   b. Other Areas: Cast metal.
5. Surface Mounted, Sheet Steel Box: Raised sheet steel.
6. Surface Mounted, Cast Box: Cast.
7. Surface Mounted, Nonmetallic Box: Manufacturer's standard.
8. Receptacle Shown as Weatherproof on Drawings: Weatherproof Type 1.

3.05 IDENTIFICATION

A. Use tape labels for identification of individual receptacles in dry indoor locations.

1. Degrease and clean device plate surface to receive tape labels.
2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
3. Identify panelboard and circuit number from which item is served on face of plate.

B. Identify conductors with durable wire markers or tags inside outlet boxes

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.

B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Using test plug, verify device and its outlet box are securely mounted.

D. Line Voltage Range: 105 volts to 132 volts.

E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.

F. Ground Impedance: 2 ohms, maximum.

G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

H. Tests shall be diagnostic, indicating damaged conductors, high resistance at 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.

END OF SECTION

SECTION 26 32 13.13
DIESEL ENGINE GENERATOR SET

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
2. California Air Resources Board (CARB).
3. Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
4. International Organization for Standardization (DIN/ISO): 9001, Quality Management Systems—Fundamentals and Vocabulary.
5. National Electric Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. MG 1, Motors and Generators.
6. National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
7. National Fire Protection Association (NFPA):
   a. 37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
   b. 70, National Electric Code.
   c. 110, Emergency and Standby Power Systems.
8. SAE International (SAE): J1074, Engine Sound Level Measurement.
9. UL:
   a. 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
   b. 508, Industrial Control Equipment.
   c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
   d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
   e. 2200, Stationary Engine Generator.

1.02 SUBMITTALS

A. Action Submittals:

1. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system.
2. Paragraph by paragraph specification compliance statement, describing differences between specified and proposed equipment.
3. Engine and generator weight, and anchoring requirements.
4. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
5. Complete list of accessories provided.
6. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.
7. Transient and subtransient reactances per unit.
8. Output waveform and telephone interference factor (TIF).
9. Circuit breaker data, including make model, catalog number, settings, and time current curves and enclosure size sized for increased connection space.
10. Cable termination lug data sheets.
11. Control panel instrument identification inscriptions.
12. Sample guarantee.
13. Electrical schematic and wiring diagrams for the following:
    a. Generator control panel.
    b. Main generator Battery charging system.
    c. Governing system.
    d. Interconnection wiring diagram for automatic transfer switch specified in Section 26 36 23, Automatic Transfer Switches.
    e. Enclosed electrical components.
14. Engine generator set motor starting capability and percent voltage dip curve.
15. Heated fuel strainer system size and voltage.
16. Jacket water heater size and voltage.
17. Subbase tank size and dimensions.
18. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
19. Exhaust system silencer pipe supports.
20. Anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.
21. Generator enclosure building, stairs, and access platforms when outdoor generator is indicated.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Calculations for generator enclosure building, stairs, and access platform, including gravity and lateral force resisting system and anchors.
3. Generator set manufacturer qualifications.
4. Generator set UL 2200 certification documentation or independent certification.
5. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
6. Factory Test Report.
7. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
8. Description of parts and service availability.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
10. Special guarantee.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by UL in conformance with those standards documented with an applied UL listing mark.

B. Manufacturer Special Requirements:

1. Generator Set: Listed to UL 2200 or submitted to an independent third-party certification process to verify compliance as installed.
2. Generator Set Manufacturer: Certified to ISO 9001 with third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.04 AIR QUALITY PERMIT

A. Provided by Owner.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:

1. Cummins.
2. Caterpillar.
3. Kohler.
4. MTU.
5. Generac.

2.02 SERVICE CONDITIONS

A. Ambient Temperature at Air Intake: 104 degrees F maximum.

B. Ambient Temperature at Engine Generator Set: 104 degrees F maximum.

2.03 GENERAL

A. Ratings:

1. Operate at 1,800 rpm.
2. Rated as indicated on Drawings at 0.8 PF, based on specified service conditions.
3. Voltage: As shown on Drawings.
4. Rated based on standby service.

B. Emissions:

1. Engines: Meet emission requirements specified in 40 CFR Chapter I Part 89 for stationary Internal Combustion (IC) engines.

C. Vibration Design:

1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
2. Apply torsional analysis and design to mitigate torsional vibration.
3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

2.04 ENGINE

A. General:

1. Manufacturer's standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

B. Type:

1. Diesel cycle, four-stroke type with unit mounted radiator and fan cooling.
2. Minimum Displacement: As recommended by generator manufacturer.
3. Minimum Number of Cylinders: As recommended by generator manufacturer.

C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter: Capable of three complete cranking cycles without overheating.
3. Batteries:
   a. Sized as recommended by engine manufacturer.
   b. Lead-acid type.
   c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
   d. Housed in acid-resistant frame isolated from engine generator main frame.
   e. Located such that maintenance and inspection of engine is not hindered.
   f. Complete with battery cables and connectors.
   g. Electric battery warmer plate.

4. Battery Charger:
    a. UL 1236 listed and labeled.
    b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
    c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
    d. Located by generator manufacturer in generator control panel, or wall mounted in generator enclosure.
    e. Include:
        1) Ammeter and voltmeter.
        2) Fused ac input and dc output.
        3) Power ON pilot light.
        4) AC failure relay and light.
        5) Low and high dc voltage alarm relay and light.
    f. Alarm relay dry contacts rated 4 amps at 120V ac.
    g. Wire battery charger status and alarm contacts back to generator control panel, terminate and identify contacts.

D. Fuel System:

1. Engine driven, mechanical, positive displacement fuel pump.
2. Fuel filter with replaceable spin-on canister element.
3. Provide fuel cooler, suitable for operation of generator set at full rated load in ambient temperature specified if required for operation due to design of engine and installation.
4. Heated fuel strainer system.
5. As specified under Article Integral Subbase Fuel Tank.
6. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

1. Electro-mechanical or electro-hydraulic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
    a. Manual speed control device.
    b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

1. Radiator:
    a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
    b. Cooling System: Rated for full load operation as specified in Article Service Conditions.
    c. Fan: Suitable for use in a system with 0.5 in water restriction.

d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.

2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
   a. Suitable for operation on service voltage as shown on Drawings.
   b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
   c. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
   a. Pressure switch to initiate shutdown on low oil pressure.
   b. Oil filter with replaceable element.
   c. Bayonet type oil level stick.
   d. Valved oil drain extension.
3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

H. Exhaust System:

1. Muffler: Rated as recommended by generator manufacturer to meet noise requirements in self-contained units specified under Article Sound Attenuation.
2. Exhaust Pipe: ASTM A335, Grade P11, standard wall, with fittings selected to match piping materials.
3. Pipe Connections: Welded.
4. Engine Connection:
   a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
   b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.

I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.

3. Stator Windings:
   a. Skewed for smooth voltage waveform.
   b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System:

1. Class H, with a maximum rise of 125 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Vacuum pressure impregnated (VPI).

C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.

E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip:
   a. Less than 20 percent at rapid application of rated load.
   b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

F. Motor Starting Capability: Assume single-step load transfer for all connected loads, unless noted otherwise on Drawings.

G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

H. Main Circuit Breaker (when indicated one-line diagram):

1. Type: Molded case.
2. Current Rating: As shown on Drawings.
3. Interrupt Rating: as recommended by generator manufacturer.
4. Compression lugs for all feeder conductors including neutral and ground.
5. Trips:
   a. Solid state, RMS sensing.
   b. Adjustable Functions:
      1) Long-time current pickup.
      2) Long-time delay.
      3) Normal range instantaneous
      4) short-time pickup.
      5) Short-time delay with I2t function.
      6) Ground fault pickup.
      7) Ground fault delay.
      8) Zone selective interlock.
6. Enclosure:
   a. Rating: NEMA 250, Type 12.
   b. Mounted with vibration isolation from engine generator set.
7. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.
8. Oversize enclosure to accommodate multiple parallel feeder conductors.

2.06 BASEPLATE

A. Mount engine generator set on a rigid common steel base frame.

B. Stiffen base frame to minimize deflections.

2.07 INTEGRAL SUBBASE FUEL TANK

A. General:

1. Full load operation of generator set for 24 hours.
2. UL 2085 listed and labeled.
3. Installation: In compliance with NFPA 37.
4. Double-walled, steel construction including the following features:
   a. Emergency tank and basin vents.
   b. Mechanical level gauge.
   c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
   d. Leak detection provisions, wired to generator set control for local and remote alarm indication.

e. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
f. Basin drain.
g. Integral lifting provisions.

2.08 VIBRATION ISOLATORS

A. Performance: Meet code requirements specified in Section 01 61 00, Common Product Requirements.

B. Provide vibration isolators, spring/pad type.

C. Include seismic restraints if required by Site location.

2.09 AUTOMATIC LOAD TRANSFER CONTROL

A. Provide automatic run controls suitable for remote interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided in Section 26 36 23, Automatic Transfer Switches.

2.10 CONTROL SYSTEM

A. Control Panel:

1. Rating: NEMA 250, Type 12.
2. Material: Steel.
3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
6. Controls: Solid-state, microprocessor based.
7. Control Panel: Designed and built by generator manufacturer to provide operating, monitoring, and control functions for generator set.
8. Control Panel Mounting Height: 6 feet 6 inches maximum above where personnel will access panel, modify mounting height if a sub-base fuel tank is used.

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.

4. Fault Indication Lamps: Manufacturer's standard.
5. Meters: Digital with analog display plus or minus 2 percent accuracy.

C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. Kilo-watts (kW).
8. Percent kW.
9. Power Factor.
10. FREQUENCY meter.
11. Engine OIL PRESSURE indicator.
12. Engine jacket WATER TEMPERATURE indicator.
13. Engine SPEED indicator (RPM).
14. Engine OIL TEMPERATURE indicator.
15. RUNNING TIME indicator.
16. DC battery voltage.
17. Emergency Stop button.

D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.

E. External Interfaces:

1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
2. Output: Dry contact rated 5 amps at 120V ac.
3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.

F. Functional Requirements:

1. LCD text display of alarm/event descriptions.
2. Recranking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recranking for a preset period of time after engine stop.

3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
4. Cooldown timer, adjustable from 5 minutes to 60 minutes.
5. Alarms:
   a. Low coolant level.
   b. Low fuel level.
   c. Low battery voltage.
   d. High battery voltage.
   e. Battery charger failure.
6. Engine shutdown upon any of the following conditions:
   a. Engine overspeed.
   b. Emergency stop button depressed.
   c. High jacket water temperature alarm setpoint and shutdown setpoint.
   d. Low oil pressure alarm setpoint and shutdown setpoint.
7. Air Inlet Damper Opening:
   a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
   b. Air Inlet Dampers: Fail open.

G. Special Requirements: Mount battery charger in control panel.

H. Power Requirements: Manufacturers stands internally connected.

2.11 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200 when shown located outside a building on Drawings.
2. Package shall comply with requirements of NEC for wiring materials and component spacing.
3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
4. Housing:
   a. Provide ample airflow for generator set operation at rated load in ambient temperature of 104 degrees F.
   b. Doors:
      1) Hinged access doors as required to maintain easy access for operating and service functions.
      2) Lockable and include retainers to hold door open during service.

3) Able to open 180 degrees without obstruction, except rear control panel door, which must open at least 135 degrees.

5. Roof: Cambered to prevent rainwater accumulation.
6. Openings: Screened to limit rodent access into enclosure.
7. Make electrical power and control interconnections within perimeter of enclosure.
8. Finishes:
   a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.
   b. Prime and paint surfaces of metal parts. Minimum coating requirements:
      1) Primer: 0.5 mil to 2.0 mils thick.
      2) Top Coat: 0.8 mil to 1.2 mils thick.
      3) Gloss:
         a) In accordance with ASTM D523, 80 percent plus or minus 5 percent.
         b) Gloss Retention After 1 Year: 50 percent minimum.
      4) Crosshatch Adhesion: In accordance with ASTM D3359, 4B-5B.
      5) Impact Resistance: In accordance with ASTM D2794, 120-inch to 160-inch pounds.
      6) Salt Spray: In accordance with ASTM B117, plus 1,000 hours.
      7) Humidity: In accordance with ASTM D2247, plus 1,000 hours.
      8) Water Soak: In accordance with ASTM D2247, plus 1,000 hours.
   c. Do not paint hoses, clamps, wiring harnesses, and other nonmetallic service parts.
   d. Provide corrosion-resistant fasteners designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure Minimum Steel Thickness: 12-gauge for framework and 14-gauge for panels.
10. Hardware and Hinges: Austenitic stainless steel.
11. Exhaust Silencer:
    a. Install factory-mounted exhaust silencer inside enclosure.
    b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
    c. Provide seamless flexible exhaust connections to generator set.
12. Maintenance Provisions:
    a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
    b. External radiator-fill provision.

c. External fuel fill provision (if equipped with a sub-based fuel tank).

13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Provide rain hoods for inlet ducts.
15. Provide external emergency stop switch that is protected from accidental actuation.
16. Sound Attenuation:
    a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 104 degrees F.
    b. Design, provide, and install enclosure to reduce sound level of generator set while operating at full rated load to a maximum of 74dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
    c. Insulate enclosure with nonhydroscopic materials.

2.12 PLATFORM FOR OUTDOOR ENCLOSURES

A. Features:

1. Cantilever supported off base with 10-gauge formed steel frame, toe plates, railing posts (pipes), rails, and grate assemblies coated with powder black.
2. Do not connect platform to subbase tank.
3. Laser cut structural materials to a tolerance of 1/16 inch, allowing no sharp edges.
4. Bolts: 5/16-inch diameter, minimum.
5. Design platform to provide access to generator enclosure service doors for maintenance and inspection and, at minimum, wrap around sides and back of generator.
6. Provide ship's ladder to access platform.
7. Platform Height: No greater than 1.5 inches above bottom of generator base frame.
8. Walkway Tread: 1-inch vertical steel grating, black powder coated, on 1-3/16-inch centers, connected by horizontal steel rods on 4-inch centers. Cover cut grate edges with 14-gauge, black powder coated, 1/2-inch by 1/2-inch angled steel.
9. Handrails: Horizontal, 42 inches above walkway.
10. Steel Component Coating: Pressure wash clean with an iron phosphate solution and apply 3 mils of high gloss black powder baked paint.
11. Platform, Walkway, and Ladder: Meet requirements of OSHA 3124.
12. Manufacturer: Generator System Support, Inc.

2.13 FACTORY FINISHING

A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

2.14 FACTORY TESTS

A. General: Conform to NFPA 110.

B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.

C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.

D. Harmonic Test: Conduct at full load conditions on the actual unit or one of the same model and size.

E. Record and Report:

1. Transient response.
2. Load/speed stability.
3. Engine fuel consumption.
4. Power output.
5. Harmonic analysis.

PART 3 EXECUTION

3.01 INSTALLATION

A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.

B. Install in accordance with NECA 404.

C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

3.02 FIELD FINISHING

A. Touch up damaged coating with paint system compatible to existing.

3.03 FIELD TESTS BY GENERATOR MANUFACTURER

A. General:

1. Conform to NFPA 110.
2. Fuel provided by Owner.

B. Performance Test:

1. Perform upon completion of installation.
2. Operate 2 hours minimum, 1 hour at 50 percent load and 1 hour at full load.
   a. Manufacture shall provide a resistive load bank and all required connecting materials for the load testing.
3. Manufacturer's representative shall make necessary adjustments.
4. Demonstrate ability of engine generator set to carry specified loads.
5. Demonstrate engine generator set safety shutdowns.

C. Test Report:

1. Record and report the following:
   a. Electric load on generator.
   b. Fuel consumption.
   c. Exhaust temperature.
   d. Ambient air temperature.
   e. Safety shutdown performance results.
   f. Noise levels at 7 meters and property line.

D. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and Owner.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Owner.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
2. National Electrical Manufacturers Association (NEMA):
   a. ICS 1, General Standards for Industrial Control and Systems: General Requirements.
   b. ICS 2, Industrial Control and Systems Controllers, Contactors, and Overload Relays not more than 2000 volts ac or 750 volts ac.
   c. ICS 6, Industrial Control and Systems: Enclosures 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. UL: 1008, Transfer Switch Equipment.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Control diagrams.
4. Conduit entrance locations.
5. Equipment ratings.
6. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory test reports.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. ASCO.

B. Cummins.

C. Eaton.

D. Russelectric.

2.02 GENERAL

A. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

B. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008.

C. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.

D. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.

1. Switches rated 400 amperes and below suitable for 100 percent tungsten-filament lamp loads.
2. Switches rated above 400 amperes suitable for 30 percent tungsten-filament lamp loads.

E. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.

F. Number of Switched Poles: As shown on one-line drawing.

G. Nominal Voltage, Full Load Current, and Short Circuit Withstand Current Rating: As shown on one-line drawing. Provide a three-cycle Withstand Current Rating, unless a longer time period is shown on the one-line drawing.

H. Switch Rating: As shown on one-line drawing.

I. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.

J. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

K. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment to be fully rated without any derating for operating conditions listed above.

2.03 ENCLOSURE

A. Type: NEMA 250, Type 1, 12, or 4 with enclosure grounding terminal.

B. Dead front, front accessible cabinet with 14-gauge welded steel construction.

C. Continuously hinged single door, with handle and lock cylinder.

D. Finish: Baked enamel applied over rust-inhibiting, phosphate based coating.

1. Exterior and Interior Color: Provide gray finish as approved by Owner.
2. Unpainted Metal Parts: Plated for corrosion resistance.

E. Type: Open for mounting in motor control center.

2.04 TRANSFER SWITCH

A. Type: Electrically operated, mechanically held, double-throw.

B. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.

C. Locking mechanism to maintain constant contact pressure.

D. Mechanical interlock switch to ensure only one of two possible switch positions or time delay in neutral position.

E. Silver alloy contacts protected by arcing contacts.

F. Main and arcing contacts visible when door is open and barrier covers removed.

G. Manual operating handle for transfer in either direction under unloaded conditions.

H. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

2.05 CONTROL MODULE

A. Completely enclosed and mounted separately from the transfer switch unit.

B. Microprocessor for sensing and logic control with inherent digital communications capability.

C. Plug-in, industrial grade interfacing relays with dust covers.

D. Connected to transfer switch by wiring harness having keyed disconnect plug.

E. Plug-in printed circuit boards for sensing and control logic.

F. Adjustable solid state undervoltage sensors for all three phases of normal and for one phase of standby source:

1. Pickup 85 percent to 100 percent nominal.
2. Dropout 75 percent to 98 percent of pickup setting.

G. Adjustable frequency sensors for standby source:

1. Pickup 90 percent to 100 percent nominal.
2. Dropout 87 percent to 89 percent of pickup setting.

H. Control module with adjustable time delays:

1. 0.5-second to 6-second engine start delay.
2. 0-minute to 5-minute load transfer to emergency delay.
3. 0-minute to 30-minute retransfer to normal delay.
4. 0-minute to 30-minute unload running time delay.

5. 0-minute to 5-minute time delay neutral on retransfer to normal source.
6. Switch to bypass any of the above time delays during testing.

I. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.

J. Exerciser, adjustable in 15-minute increments, 7-day dial clock.

1. Complete with door mounted NO LOAD and LOAD selector switch.

K. In-phase monitor to control transfer when both sources are within acceptable phase angle limits, or adjustable pneumatic type time delay relay for time-delay-in neutral position.

L. Adjustable 0-minute to 5-minutes time delay relay for engine starting signal.

2.06 METERING INSTRUMENTS

A. Connect meters to load side of transfer switch.

B. Show voltage, current, and kW on an average and per-phase basis, and track and record peak kW.

2.07 INDICATORS

A. Type: Manufacturer's standard.

B. Green lens to indicate switch position for normal power source.

C. Red lens to indicate switch position for standby power source.

D. Green lens to indicate normal power source is available within parameters established by pickup and dropout settings.

E. Red lens to indicate standby power source is available within parameters established by pickup and dropout settings.

F. Provide one normally open and one normally closed, 5 amperes, 120-volt contact for remote indication when transfer switch is in either position.

2.08 FACTORY TESTS

A. Test to ensure correct:

1. Operation of individual components.
2. Sequence of operation.
3. Transfer time, voltage, frequency, and time delay settings.

B. Dielectric strength test per NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance, final adjustment, and initial energization of equipment.
2. 1 person-day for functional testing and adjustment of relay settings.

B. Furnish startup services and training of Owner's personnel at such times as requested by Owner.

END OF SECTION

SECTION 26 42 01
PIPE BONDING AND TEST STATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American National Standards Institute (ANSI).
3. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
4. American Water Works Association (AWWA):
   a. C110, Ductile-Iron and Gray-Iron Fittings for Water.
   b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied.
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C216, Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   e. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
5. American Wood Preservers' Association (AWPA):
   a. C2, Lumber, Timber, Bridge Ties, and Mine Ties-Preservative Treatment by Pressure Processes.
   b. P9, Standards for Solvents and Formulations for Organic Preservative Systems.
6. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   c. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C150, Standard Specification for Portland Cement.
   f. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   g. F436, Standard Specification for Hardened Steel Washers.
7. Concrete Reinforcing Steel Institute (CRSI).
8. NACE International (NACE): SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

9. National Electrical Manufacturers Association (NEMA):
    a. C80.1, Electrical Rigid Steel Conduit (ERSC).
    b. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
    c. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
10. NSF International (NSF).
11. The Society for Protective Coatings (SSPC):
    a. SP 1, Solvent Cleaning.
    b. SP 10, Near-White Blast Cleaning.

1.02 DEFINITIONS

A. Electrical Isolation: Condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in NACE SP0169.

B. Electrically Continuous Pipeline: Pipeline that has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

C. Ferrous Metal Pipe: Pipe made of steel or iron, or pipe containing steel or iron as a principal structural material, except reinforced concrete pipe.

D. Foreign-Owned: Buried pipe or cable not specifically owned or operated by Owner.

E. Lead, Lead Wire, Joint Bonds, Pipe Connecting Wires, Cable: Insulated copper conductor; the same as wire.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog cuts and information for products proposed for use.
2. Decoupling device design details.

B. Informational Submittals:

1. Decoupling device manufacturer's proposed method of installation.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory test reports for isolation fitting.
4. Field Test Reports, including results of insulator testing.
5. Qualifications of Cathodic Protection Specialist.

1.04 QUALITY ASSURANCE

A. Cathodic Protection Specialist Qualifications: NACE International certified.

1.05 SCHEDULING

A. Specified weld-in fittings may have long delivery times; contact manufacturers and obtain commitments for delivery before scheduling installation.

PART 2 PRODUCTS

2.01 WIRES

A. Conform to applicable requirements of NEMA WC 70.

B. Joint Bond:

1. General: Single-conductor, stranded copper wire with 600-volt HMWPE insulation. Supply joint bonds complete with formed copper sleeve on each end of wire. Where acceptable two flat straps 2-inches wide by 1/4-inches thick may be used.
2. Push-on, Mechanical, or Flanged Joints: 2 AWG wires, 18-inches long.
3. Flexible Coupling Joints: 2 AWG wires, 24-inches long, with two 12-inch-long XHHW insulated 12 AWG wire pigtails, as manufactured by Erico Products Inc. (Cadweld), Cleveland, OH.
4. Isolated Flexible Coupling Joints: 8 AWG wire, 18 inches long, with one 12-inch-long XHHW insulated 12 AWG wire pigtail.
5. Concrete Cylinder Pipe: 2 AWG bond wires, for each joint. Bond wires shall be 9 inches long with sufficient insulation removed from each end of wire to allow field welding.

C. Pipe Connecting: Single-conductor, 4 AWG stranded copper wire with 600-volt HMWPE insulation.

D. Test Station: Single-conductor, 12 AWG stranded copper with 600-volt TW, THWN, or THHN insulation and single-conductor, 8 AWG stranded copper with 600-volt HMWPE insulation, 6 AWG stranded copper with 600-volt HMWPE insulation.

E. Galvanic Anode Header Wire: Single-conductor, No. 6 AWG or thicker wire only, stranded copper with 600-volt HMWPE insulation.

F. Coupon: Single-conductor, two No. 12 AWG stranded copper wire with 600-volt TW, THWN, or THHN insulation.

G. Reference Cell: Single-conductor, one 12 AWG stranded copper wire with 600-volt TW, THWN, or THHN insulation.

H. Polarization Cells: Single-conductor, 2/0 AWG stranded copper with 600-volt HMWPE insulation, or as required by manufacturer.

I. Insulation Colors:

1. Galvanic Anodes: Black.
2. Pipeline Test Wires: White.
3. Reference Electrodes: Yellow.
4. Casing Test Wires: Orange.
5. Isolated Joints: As shown on Drawings.

J. Wire Labels:

1. Materials shall be suitable for permanent identification.
2. Plastic, paper, or cloth markers will not be permitted.
3. Each pipe test wire shall include pipe diameter and pipe type, reference electrode, casing, or galvanic anode, as applicable.

2.02 CATHODIC PROTECTION TEST STATIONS

A. Post Mounted (Standard):

1. Test Box: Cast aluminum suitable for threaded mounting to a 3-inch or larger rigid galvanized conduit.
2. Terminal Block: Plastic or glass-reinforced laminate, 1/4 inch thick with five terminals. Terminals shall have special heads to keep them from turning or shall be easily accessible from both sides of terminal block without requiring its removal. Terminal studs, washers, and nuts shall be Type 304 stainless steel.
3. Mounting Structure: 3-inch Schedule 40 galvanized steel post, as shown on Drawings.
4. Mounting Hardware: Galvanized steel.
5. Manufacturer and Product: Testox; 900 series test station.

B. Post Mounted (Foreign Gas Line and Casing):

1. Test Box: Cast aluminum suitable for threaded mounting to a 3-inch or larger rigid galvanized conduit.
2. Terminal Block: Plastic or glass-reinforced laminate, 1/4-inch thick with five terminals. Terminals shall have special heads to keep them from turning or shall be easily accessible from both sides of terminal block without requiring its removal. Terminal studs, washers, and nuts shall be Type 304 stainless steel.
3. Mounting Structure: 4-inch by 4-inch by 5-foot long preservative treated wood post. Wood post shall be pressure treated with

waterborne preservative intended for fresh water or soil contact in accordance with AWPA C2 and AWPA P9.

4. Mounting Hardware: Conduit straps and hardware required to mount test station to post shall be galvanized steel.
5. Manufacturer and Product: Testox; 2000 Series test station.

2.03 PERMANENT REFERENCE ELECTRODES

A. Prepackaged Copper-Copper Sulfate Reference Electrodes:

1. Material: Permanent type, copper-copper sulfate reference electrode suitable for direct burial with a minimum design life of 15 years.
2. Dimensions: 1-1/2-inch diameter by 6 inches long, minimum.
3. Wire: 12 AWG stranded copper wire with yellow, 600-volt RHH-RWH insulation. Wire shall be attached to electrode and insulated with manufacturer's standard connection. Connection shall be stronger than the wire.
4. Manufacturers and Products:
   a. Borin Manufacturing; Model SRE-007-CUY.
   b. Electrochemical Devices, Inc.; Model UR-CUG-CW.
   c. GMC Electrical, Inc.; Model CU-1-UGPC.

2.04 THERMITE WELD MATERIALS

A. General:

1. Thermite weld materials consist of wire sleeves, welders, and weld cartridges according to weld manufacturer's recommendations for each wire size and pipe or fitting size and material.
2. Welding materials and equipment shall be product of a single manufacturer. Interchanging materials of different manufacturers is not acceptable.

B. Molds: Graphite; ceramic "One-Shot" molds will not be accepted.

C. Adapter Sleeves:

1. For 12 AWG and 2 AWG wires.
2. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in field are acceptable. Attach field-formed joint bond sleeves with appropriate size and type of hammer die furnished by thermite weld manufacturer.
3. Extend wire conductor 1/4 inch beyond end of sleeve.

D. Cartridges: Cast-iron thermite weld cartridges for cast and ductile iron pipe and fittings.

1. Maximum Cartridge Size: 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.

E. Welders and Cartridges: For attaching copper wire to pipe material:

Pipe Material	Weld Type	Cartridge Size, Max.
4 AWG Wire and Smaller:		
Steel	HA, VS, HC	25 gm
Ductile Iron	HB VH, HE	32 gm
Cast Iron	HB, VH, HE	32 gm
2 AWG Joint Bonds:		
Steel	FS	25 gm
Ductile or Cast Iron	FC	32 gm
Concrete Cylinder Pipe	HA, GR	32 gm

F. Welding Materials Manufacturers:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

G. Thermite Weld Coating:

1. Thermite Weld Caps: Prefabricated weld cap with coating and suitable primer, such as Handy Cap II with Royston Primer 747, as manufactured by Royston Laboratories, Inc.
2. Use products recommended by pipe or fitting coating manufacturer to repair spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

2.05 ANCILLARY MATERIALS

A. Mastic Coating: TC Mastic (Brush Applied) as manufactured by Tapecoat Co., Evanston, IL.

B. Wire Connectors: One-piece, tin-plated crimp-on lug connector as manufactured by Burndy Co. or Thomas and Betts.

C. Compression Connectors:

1. For in-line, tap, and multisplice furnish “C” taps made of conductive wrought copper, sized to fit wires being spliced.
2. Manufacturer and Product: Burndy; Type “YC.”

D. Silver Brazing Alloy: 15 percent silver content; 1,185 degrees F to 1,300 degrees F melting range.

E. Electrical Tape:

1. Linerless rubber high-voltage splicing tape and vinyl electrical tape suitable for moist and wet environments.
2. Manufacturer and Products: 3M Products; Scotch 130 C and Scotch 88.

F. Shunts: 0.01-ohm Holloway Type RS.

2.06 CONCRETE

A. Furnish as specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 ISOLATING JOINTS

A. Isolating Joints: Dielectric unions, flanges, or couplings.

1. Complete assembly shall have a rating equal to or higher than that of joint and pipeline.
2. Materials shall be resistant for the intended exposure, operating temperatures, and products in the pipeline.

B. Flange Insulating Kits:

1. Flanges: For steel pipe flanges, oversize bolt holes as specified in Section 33 05 01, Conveyance Piping—General.
2. Fasteners: In accordance with AWWA C207 or AWWA C110, for steel pipe or ductile iron pipe, respectively. Minimum bolt length shall be the sum of the mating flanges maximum thicknesses, sealing gasket, insulating and steel washer thickness, and depth of the nut plus 1/8 inch minimum before torquing. Since insulating sleeves may not fit over unthreaded portions of fasteners, bolts shall be cut thread full body or threaded rod as required to meet inside diameter dimensions of insulating sleeves specified herein.
3. Gaskets: Full-face Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
4. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA G-10 grade).

5. Insulating Washers: Fiberglass reinforced epoxy (NEMA G-10 grade).
6. Steel Washers: Hardened steel, ASTM F436, 1/8 inch thick.
   a. Provide two washers per bolt for flange diameters equal to or less than 36-inch diameter.
   b. Provide four washers per bolt for flange diameters larger than 36-inch diameter.
7. Manufacturers:
   a. PSI, Houston, TX.
   b. Advance Products and Systems, Lafayette, LA.

C. Weld-In Isolation Fitting:

1. Pre-assembled, weld-in isolation fitting.
2. Pipe Material: API 5L, Grade B.
3. Dimensions: Weld-in isolation fitting shall have the same dimensions as pipe to which fitting is welded, suitable for butt-weld installation to pipe.
4. Pressure Rating: Wall thickness based on design pressures shall meet requirements of Section 33 05 01.01, Welded Steel Pipe and Fittings.
5. Dielectric Properties: Measured across the weld-in isolation fitting in air shall be 5-million ohms minimum resistance with a 3,000-volt minimum voltage breakdown.
6. Protective Coatings and Linings:
   a. Surface Preparation: Near White Metal Blast, SSPC SP-10.
   b. Interior Protective Lining: Match pipeline lining material.
   c. Exterior Protective Coating:
      1) Dielectric Coated Steel Pipe: 100 percent solids epoxy or polyurethane designed for use as a pipeline coating as manufactured by Madison Chemical, Milton, Ontario, Canada; Futura Coatings, Hazelwood, MO. Minimum dry film thickness shall be 60 mils.
      2) Cement Mortar Coated Steel Pipe: Cement mortar in accordance with AWWA C205.
7. Coating Application: Apply interior linings and exterior coatings in accordance with manufacturer's written instructions. 100 percent solids materials shall be applied by applicators approved by coating supplier.
8. Testing: Provide electrical testing of the isolation fitting after fabrication. Minimum electrical resistance shall be as specified herein. Test pressure shall be in accordance with Section 33 05 01.01, Welded Steel Pipe and Fittings.
9. Manufacturers and Products:
   a. Advanced Products and Systems, Inc., Lafayette, LA; IsoJoint.
   b. PSI, Houston, TX; ElectroStop.

D. Flexible Insulated Couplings: As specified in Section 33 05 01.01, Welded Steel Pipe and Fittings.

E. Tie-Rod Insulator: One-piece Minlon insulating sleeve and washer. Provide two hardened steel washers per insulator, ASTM F436, 1/8 inch thick.

F. Insulating Unions: O-ring sealed with molded and bonded insulating bushing to union body, as manufactured by Central Plastics Co., Shawnee, OK.

2.08 SOLID STATE DECOUPLERS (SSD) – DC BLOCKERS

A. Solid-state decoupling device with the following ratings:

60-Hz Current short duration, 3 cycles	5,000 amps AC-RMS Symmetrical
60-Hz Current steady-state, 65 degrees C ambient	40 amps AC-RMS Symmetrical
Lightning Surge Current	100,000 amperes
DC Current Leakage driving voltage of 1V dc, 65 degrees C	Less than 0.1 milliamp
Ambient Operating Temperature	Minus 40 degrees F to Plus 150 degrees F

B. Provide polarization cell in manufacturer's standard enclosure Dairyland Electric Industries, Model SSD 3.7KA.

C. Mounting Hardware: Manufacturer's standard, as approved by Engineer.

2.09 FUNCTIONAL TEST EQUIPMENT

A. Test Equipment: Before construction begins, obtain test equipment necessary for electrical continuity testing, and the following equipment:

1. Models 601, Aboveground and 702, Buried Insulation Checkers, as manufactured by Gas Electronics Co., Seymour, MO.
2. One Model 77 Series III, Digital Multimeter, with case and test leads, as manufactured by Fluke Corporation, Everett, WA.
3. Two Model 6B copper-copper sulfate reference electrodes as manufactured by Tinker and Rasor, San Gabriel, CA.
4. One quart of copper sulfate antifreeze solution.
5. One-half pound of copper sulfate crystals.

B. Store test equipment at Site and maintain in accurately calibrated, working condition. Test equipment shall be available to Engineer for testing purposes. Upon completion of Project, test equipment listed above shall be turned over to Owner in clean, accurate, and fully functional condition, along with operating manuals, test wires, and cases supplied with equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Construct system of pipe joint bonds to form an electrically continuous pipeline, isolating joints, grounding cells, and test stations as shown on Drawings.

3.02 PIPE JOINTS BONDING

A. Electrically bond joints of buried steel and iron pipe, including vault and manhole piping and fittings, and including restrained joints, except joints specified to be threaded, welded, or isolated as shown on Drawings.

B. Install two joint bond wire assemblies at each joint that requires bonding.

C. Use thermite weld process for electrical connection of wires to pipe and fittings.

D. Test each bonded joint for continuity.

E. Joint bonds for cast-iron soil pipe and fittings and high silicon cast-iron pipe and fittings shall be in accordance with manufacturer's recommendations. Bronze wedges are not an acceptable method of achieving electrical continuity.

3.03 TEST STATION INSTALLATION

A. Determine location of test stations based on actual site conditions and as approved by Engineer.

B. Locate test stations where shown on the Schedules on Drawings.

1. Install test stations as appropriate at 1,000-foot intervals or less.
2. Install Type F test stations where any ferrous metal pipe crosses a foreign owned pipeline under cathodic protection.
3. Install Type C test station at both ends of cased crossings.

C. Attach test wires to pipe.

D. Wires to foreign-owned pipelines will be attached by pipeline owner, unless permission is granted to Contractor in writing by owner of foreign pipeline. Coordinate this Work with owner of foreign pipeline before pipe is excavated.

E. Locate post mounted test stations where shown on Drawings, and at protected locations such as fences, road crossings, and edges of cultivated land.

F. Bury test and reference electrode wires a minimum of 36 inches below finished grade.

G. Make wire connections to test station terminals with crimp-on spade lug terminals, except where solid wire is specified or terminal strips with tubular clamps are used.

H. Provide 12-inch loop in wires, both at pipe and at test station to prevent them from being stressed or broken during back filling.

I. Wire Labels:

1. Install on conductors in boxes.
2. Position markers in boxes so they do not interfere with operation and maintenance.

3.04 CONDUITS

A. Secure conduits entering test station boxes with double locknuts, one on outside and one on inside.

B. Install insulated bushings and insulated throat connectors on ends of rigid metallic conduit.

C. Use watertight couplings and connectors. Install and equip boxes and fitting to prevent water from entering conduit or box. Seal unused openings.

3.05 CONCRETE

A. Concrete for flush mounted test stations shall conform to requirements for concrete in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing: Accurately place in accordance with CRSI Recommended Practice.

C. Minimum Compressive Strength at 7 Days: 2,500 psi.

D. Placing, Consolidating, and Finishing: In accordance with ACI 301.

3.06 COUPONS

A. Install coupons in the same backfill as the pipeline at the dimension specified on Drawings.

3.07 REFERENCE ELECTRODE INSTALLATION

A. Remove plastic or paper wrapper and place reference electrode within pipeline trench excavation 6 inches from below centerline of pipe in a vertical or horizontal position. Install reference electrode within 18 inches of foreign pipelines between foreign and Owner's pipeline.

B. Place native trench material around the reference electrodes, 6 inches minimum. Terminate wires in test stations.

3.08 WIRE CONNECTIONS

A. Thermite Weld:

1. Use thermite weld method for electrical connection of copper wire to steel, ductile, and cast-iron surfaces. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation recommended by welder manufacturer. Ensure that pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.
2. After weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace defective connections.
3. On pipe and fittings with dielectric linings, make weld connection on shop tab provided or on a thick metal section to minimize damage to lining and coating. After weld is made, coat weld with coating repair material.
4. Install prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations. Repair damage to pipe lining in accordance with lining applicator's recommendations. Repair exposed metal surfaces not covered by resin or pipe coating in accordance with coating manufacturer's recommendations.
5. Make wire connections to concrete cylinder pipe by thermite welding to shop welded steel studs or plates provided on pipe for this purpose. Clean steel studs to bright metal before thermite welding. Coat completed wire connection with cement mortar.

3.09 WIRE INSULATION REPAIR

A. Handle wires with care. Splices for damage to wire insulation shall be required by spirally wrapping (50 percent overlap, minimum) with two coats of high-voltage rubber splicing tap and two layers of vinyl electrical tape. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder. Splices shall be approved by Engineer.

3.10 ISOLATED JOINTS

A. Install isolated joints to electrically isolate pipeline from other structures Section 33 05 01.01, Welded Steel Pipe and Fittings and where shown on Drawings. Locate isolated joints at connections to existing metallic pipe, where cathodically protected pipe connects to pipe not intended to have cathodic protection, and where shown.

B. Align and install insulating joints as shown on Drawings and according to manufacturer's recommendations.

C. Do not use fastener lubricants that contain graphite or metallic compounds that will interfere with the insulating capability of the completed joint.

D. Test the completed insulating joint as specified herein.

E. Weld-In Isolators:

1. Welding and testing for shall be as specified in Section 33 05 01.01, Welded Steel Pipe and Fittings.
2. Provide heat shrink sleeves at each welded joint as specified in section 33 05 01.01, Welded Steel Pipe and Fittings.
3. Touch up damaged coating on exterior of insulating fitting with repair kits provided by coating manufacturer.
4. Repair linings at welds with cement mortar in accordance with AWWA C205. Repair linings shall be NSF approved for potable water contact.

F. Insulating Flange Lining and Coating:

1. After assembly of insulated flanges, repair coatings and linings as shown on Drawings and as specified herein.
   a. Interior Lining: Repair linings as specified in Section 09 90 10, Pipeline Coating and Lining. For cement mortar linings, prepare cement-mortar surface in accordance with paint manufacturer's instructions and apply a 20-mil minimum thickness of NSF potable water approved, 100 percent solids water or air curing epoxy coating to interior of pipeline. Apply

coating for a minimum of two pipe diameter lengths from insulating flange in both directions. Apply and cure coating in accordance with manufacturer's recommendations. Do not apply coating where it will interfere with operation of pipeline valves or other pipeline assemblies.

b. Exterior Coating: For buried insulating flanges, coat completed joint with petroleum wax tape in accordance with AWWA C217.

3.11 SOLID STATE DECOUPLING DEVICES

A. Provide solid state decoupling devices for isolating joints as shown on Drawings. Mount decoupling devices to wall adjacent to pipe in accordance with manufacturer's standards, as approved by Engineer, and where indicated on Drawings.

3.12 FIELD QUALITY CONTROL

A. Electrical Continuity Testing:

1. Provide necessary equipment and materials and make electrical connections to pipe as required to test continuity of bonded joints.
2. Conduct continuity test on buried joints that are required to be bonded. Test electrical continuity of joint bonds after bonds are installed but before backfilling of pipe.
3. Have Cathodic Protection Specialist monitor tests of bonded joints.
4. Test electrical continuity of completed joint bonds using either a digital low resistance ohmmeter or by Calculated Resistance Method, at Contractor's option.
    a. Digital Low Resistance Ohmmeter Method:
        1) Provide the following equipment and materials:
            a) One Biddle Model 247001 digital low resistance ohmmeter.
            b) One set of duplex helical current and potential hand spikes, Biddle Model No. 241001, cable length as required.
            c) One calibration shunt rated at 0.001 ohm, 100 amperes, Biddle Model No. 249004.
        2) Test Procedure:
            a) Measure resistance of joint bonds with low resistance ohmmeter in accordance with manufacturer's written instructions.
            b) Use helical hand spikes to contact pipe on each side of joint, without touching thermite weld or bond.
            c) Clean contact area to bright metal by filing or grinding and without surface rusting or oxidation.

d) Record measured joint bond resistance on test form described herein.
e) Repair damaged pipe coating.

b. Calculated Resistance Method:
1) Provide the following equipment and materials:
a) One dc ammeter (meter or clamp-on) with full scale reading of 100 amperes and a minimum resolution of 1 ampere or a 100-ampere shunt with a voltmeter as specified herein.
b) One high resistance electronic voltmeter with a dc low range of 200 millivolts full scale to a dc high range of 20 volts full scale and capable of a minimum resolution of 1 millivolt (two voltmeters are required if a shunt is used).
c) One knife switch, safety switch, or time controlled relay suitable for test current.
d) Two electrical probes for the voltmeter.
e) Insulated wire suitable for carrying the test current, length as required.
f) One dc power supply with a steady capacity of 50 amperes minimum; storage batteries are not an acceptable power supply.
g) Test Procedure: Either tightly clamp or thermite weld current wire connections to the pipe. Determine wire size for the test current, and do not exceed 1,000 feet in length.

c. Apply a minimum direct current of 50 amperes.
d. Measure voltage drop across each joint with voltmeter by contacting pipe on each side of joint. Voltmeter connections to bond wire or thermite welds will not be acceptable.
e. Measure current applied to test span and voltage drop across joint simultaneously.
f. Record measured voltage drop and current for each joint of test form described herein and calculate bond resistance in accordance with the following formula:

$$R = E/I$$

Where:
R = Resistance of the joint bond.
E = Measured voltage drop across the joint, in volts.
I = Test current applied to the pipe test span, in amperes.

5. Joint Bond Acceptance:
   a. Joint Bond Resistance: Less than or equal to the maximum allowable bond resistance values in Table 1.

Table 1		
Joint Type	Max. Allowable Resistance	
	1 Bond/Joint	2 Bonds/Joint
Push-On Mechanical	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm
Concrete Cylinder	0.000200 ohm	0.000100 ohm

   b. Replace joint bonds that exceed the allowable resistance. Retest replacement joint bonds for compliance with bond resistance.
   c. Repair defective joint bonds discovered during energizing and testing.
6. Record Tests of Each Bonded Pipeline:
   a. Description and location of pipeline tested.
   b. Starting location and direction of test.
   c. Date of test.
   d. Joint type.
   e. Test current and voltage drop across each joint and calculated bond resistance (Calculated Resistance Method only).
   f. Measured joint bond resistance (Digital Low Resistance Ohmmeter method only).
   g. Record test information on a form that includes information listed above.

B. Isolated Joint Testing:

1. Test each isolating joint after assembly with a GAS Electronics Model 601 isolator tester or equivalent instrument in accordance with the manufacturer's written instructions. Conduct test before burial and coating of buried isolating flanges.
2. Contractor to replace damaged or defective isolation parts identified during testing.
3. Provide Engineer with 3 days' advance notice before beginning tests.
4. Cathodic Protection Specialist shall monitor the tests.
5. Test each joint after assembly with insulator tester in accordance with manufacturer's written instructions.
6. For insulating flanges, test and record insulating values of each bolt in addition to the completed flange.
7. Replace damaged or defective insulation parts.
8. Correct defects identified during testing.
9. Additional Electrical Isolation Testing: Perform electrical isolation testing on items such as wall sleeves, carrier casings, and

reinforcing steel to ensure pipeline is electrically isolated from vaults and structures not intended to receive cathodic protection current. Provide documentation that these items have been tested and found to not have any electrical shorts.

10. Electrical isolation is defined as a condition of being electrically isolated from other metallic structures (including, but not limited to, other piping, concrete reinforcement, casings, and other structures not intended to be cathodically protected) and the environment as defined in AMPP Recommended Practice RP0169-83.
11. Owner shall conduct additional isolating joint tests as required to ensure that isolating flanges are not electrically shorted by other equipment, electrical conduits, or incidental contact with concrete reinforcement during energizing and testing.

C. Pipe and Metal Reinforcement Electrical Isolation Testing:

1. Perform electrical isolation testing between pipelines and metal reinforcement at wall and floor penetrations, as described herein. Provide reports as part of the Quality Assurance Submittals.

D. Contractor Shall:

1. Coordinate with a Cathodic Protection Specialist during metal reinforced wall and floor piping penetrations.
2. Notify Cathodic Protection Specialist 3 full working days in advance before starting to place concrete.
3. Ensure reinforcement around the pipeline, and any metallic appurtenance attached to the pipeline, are well restrained and will not move during cement pouring.
4. Take photographs demonstrating proper separation between pipeline and reinforcement. Photographs shall have a date and time stamp and be correlated to each penetration for ease of reference.
5. Remediate all electrical shorts between the pipeline and penetration reinforcement.

E. Prior to penetrations being poured with cement the Cathodic Protection Specialist shall:

1. When piping is in contact with soil, monitor pipeline potentials with respect to a copper-copper sulfate reference electrode.
2. Measure the resistance between the pipeline and reinforcement using a Low Resistance Ohmmeter.
3. Document testing results and verify the pipeline is electrically isolated from reinforcement.
4. If the pipeline is electrically shorted to reinforcement, stop work and notify the Construction crew the electrical short needs to be remediated before further penetration construction continues.

F. During penetration pours, Cathodic Protection Specialist shall:

1. Perform the same testing and documentation described in Item 2 above periodically throughout the pour, with at least two measurements having been taken. At least one measurement shall be documented during the first half of the pour and another measurement documented during the second half of the pour.
2. If the pipeline becomes electrically shorted to reinforcement during the pour, stop work and notify the Construction crew the electrical short needs to be remediated before further construction continues.

G. Once concrete has cured for a minimum of 7 days and before the pipeline penetration has been backfilled, Cathodic Protection Specialist shall:

1. Perform the same testing and documentation described in Item 2 above.
2. Document and report to the Contractor if the pipeline remained electrically isolated once the concrete cured in place.

H. DC Blocker Testing: Test each DC blocker and certify it performs all requirements specified and that it prevents hazards of induced current shocking to persons.

3.13 FUNCTIONAL TESTING

A. Perform functional testing in presence of Engineer.

B. When construction of all cathodic protection test stations is completed, notify Engineer that installation will be ready to be turned on after completion of functional testing.

C. Measure CP Native Potentials (i.e., baseline pipe-to-soil potentials) at all test stations prior to activating the cathodic protection system. Measure the CP Native potentials of electrically grounded equipment inside all vaults and structures along the pipeline. Where two wires are attached to the same pipeline, measure and record the CP Native Potentials for both wires. If the potential measurements for the same pipeline differ by more than 5 millivolts, investigate the cause. and correct the issue until the potential measurement differs by less than 5 millivolts.

D. At corrosion test stations constructed with buried copper/copper sulfate reference electrodes (i.e., stationary reference electrode) measure CP Native Potentials of the pipeline using both the stationary reference electrode and a portable copper sulfate reference electrode before the CP system is activated.

E. Provide a minimum of 5 days advance notice to the Engineer before the cathodic protection activation will be performed to allow for coordination and observance of these tests.

F. At such a time as Engineer may indicate, energize installation. At this time, conduct operating test to demonstrate equipment is installed correctly and operating properly for initial Engineer approval.

G. Tabulate structure-to-soil potential measurements, with date and test location.

END OF SECTION

SECTION 26 42 02
GALVANIC ANODE CATHODIC PROTECTION SYSTEM

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section covers the Work necessary to furnish and install a galvanic anode cathodic protection system, test stations, electrical isolation, DC blockers, and electrical continuity were required, complete.

B. Where the CUWCD WSP crosses and metal gas pipeline, cathodic test stations are required for both the CUWCD WSP and the metal gas pipeline. Provide the test station for the CUWCD WSP per this (CUWCD) specification and Contract Drawings. Also, provide one test station for each metal gas pipeline where it crosses the CUWCD WSP. Coordinate with each gas company to provide a gas-company-compliant test station, anodes, wires, and components compliant with the gas company's standards.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   c. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
   d. A615/A615M, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   e. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes
   f. B843, Standard Specification for Magnesium Allow Anodes for Cathodic Protection.
   g. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   h. C150, Standard Specification for Portland Cement.
   i. C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   j. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

k. G97, Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications.

3. Canadian Standards Association (CSA).
4. Concrete Reinforcing Steel Institute (CRSI).
5. Association for Materials Protection and Performance (AMPP), formerly NACE International and SSPC.
6. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Rigid Steel Conduit, Zinc Coated Specification for.
   c. C80.6, I Intermediate Metal Conduit (IMC)—Zinc Coated.
   d. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   e. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   f. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
   g. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
8. Society for Protective Coatings (SSPC), now part of AMPP:
   a. SP 1, Solvent Cleaning.
   b. SP 6, Commercial Blast Cleaning.
9. UL:
   a. 6, Standard for Safety Electrical Rigid Metal Conduit Steel.
   b. 360, Standard for Safety Liquid-Tight Flexible Steel Conduit.
   c. 514B, Standard for Safety Conduit, Tubing, and Cable Fittings.
   d. 1242, Standard for Safety Intermediate Metal Conduit.

1.03 QUALIFICATIONS

A. Obtain the services of a qualified Cathodic Protection Specialist to inspect, activate, adjust, and evaluate the effectiveness of the cathodic protection system. The Cathodic Protection Specialist shall be a registered professional engineer with certification or licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person accredited or certified by NACE International at the level of Corrosion Specialist or Cathodic Protection Specialist (i.e., NACE International CP Level 4). The Cathodic Protection Specialist shall have not less than 5 years of experience inspecting pipeline cathodic protection systems.

   1. Onsite inspection/testing can be performed by a Cathodic Protection Technician or equivalent. The Cathodic Protection Technician shall

be a person accredited or certified by NACE International at the level of Cathodic Protection Technician (i.e., NACE International CP Level 2). Cathodic Protection Technician shall have not less than 5 years of experience testing cathodic protection systems and be under the direct supervision of a Cathodic Protection Specialist.

2. The Cathodic Protection Specialist shall attend the final Cathodic Protection System Activation Survey.

1.04 DEFINITIONS

A. Electrical Isolation: The condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in AMPP Recommended Practice RP0169-83.

B. Electrically Continuous Pipeline: A pipeline which has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

C. Ferrous Metal Pipe: Pipe made of steel or iron, and pipe containing steel or iron as a principle structural material, except reinforced concrete.

D. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the Owner.

E. Lead, Lead Wires, Joint Bonds, Cable: Insulated copper conductor; the same as wire.

F. Pipe Section: A single fitting or a single piece of pipe less than 20 feet in length. Pipe Sections between 20 feet and 40 feet in length shall be treated as two Pipe Sections. Each 20 feet of pipe and fittings with joint bonds may be treated as one Pipe Section.

1.05 SUBMITTALS

A. Action Submittals: Catalog cuts and other information for products to be used.

B. Informational Submittals:

1. Compliance Statement: Provide compliance statement that galvanic anode composition meets chemical requirements specified herein.
2. Test data for open circuit potential measurements and electrochemical capacity for high potential magnesium anodes, as specified herein.
3. Field test reports.
4. Cathodic Protection Specialist qualifications.

C. Quality Assurance Submittals:

1. Manufacturer's Certificates of Compliance.
2. Cathodic Protection System Activation Report: Report shall include all field data and analysis and basis for and be signed and certified by the Contractor's Cathodic Protection Specialist stating that the corrosion protection criteria in this specification have been met. Data shall include but not be limited to pipe to soil potentials to permanent and temporary reference cell prior to cathodic protection system activation (so called "native" conditions), as well as polarized pipe to soil potentials on the subject pipeline as well as testing on any foreign or crossing lines.
3. Qualifications of Cathodic Protection Specialist and Cathodic Protection Technician with a minimum of 5 years of experience in the field of cathodic protection and corrosion.
4. Piping Wall and Floor Penetration Electrical Isolation Reports.

1.06 QUALITY ASSURANCE

A. Qualifications of Cathodic Protection Specialist: AMPP certified cathodic protection specialist or registered professional engineer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Provide electrode packaged in a plastic or heavy paper bag of sufficient thickness to protect electrode, backfill, and cloth bag during normal shipping and handling.

B. Store prepackaged anodes off the ground and keep them dry. Protect against weather, condensation, and mechanical damage. Immediately remove wet or mechanically damaged prepackaged anodes from Site. Handle anodes with care to prevent loss of backfill material. Do not lift or hold anodes by lead wire.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials provided hereunder shall be the product of one manufacturer to achieve standardization for appearance, maintenance, and replacement.

B. The use of a manufacturer's name and model or catalog number is for establishing the standard of quality and general configuration desired only. Products of other manufacturers will be considered in accordance with the General Conditions.

C. Materials and workmanship as specified in this section shall be installed concurrently with pipe installation. Coordinate all Work specified herein with related sections.

2.02 SUPPLIERS

A. Alternate suppliers will be considered, subject to approval of the Owner. Address given is that of the general office; contact these offices for information regarding the location of their representative nearest the Project Site.

1. Corrpro, Medina, OH.
2. Farwest Corrosion Control, Gardena, CA.
3. Mesa Products, Tulsa, OK.

2.03 GALVANIC ANODES

A. Magnesium Anodes:

1. Composition: High potential magnesium, ASTM B843, Grade M1C.
   a. Aluminum: 0.01 percent maximum.
   b. Manganese: 0.5 percent to 1.3 percent.
   c. Zinc: 0.02 percent maximum.
   d. Silicon: 0.05 percent maximum.
   e. Copper: 0.02 percent maximum.
   f. Nickel: 0.001 percent maximum.
   g. Iron: 0.03 percent maximum.
   h. Total Others: 0.05 percent each or 0.3 percent maximum, total.
   i. Magnesium: Remainder.
2. Open Circuit Potential and Electrochemical Capacity:
   a. Open Circuit Potential: Negative 1.70 volts or more negative to a copper-copper sulfate reference electrode.
   b. Electrochemical Capacity: 490 ampere hours at 50 percent efficiency, minimum.
   c. As determined by laboratory testing using ASTM G97.
3. Dimensions:
   a. Length: 64 inches minimum.
   b. Bare Weight: 60 pounds minimum.

B. Anode Wire: Furnish each anode with 12 AWG stranded copper wire with THWN insulation, 10 feet long.

C. Wire-to-Anode Connection: Manufacturer's standard. Anode connection shall be stronger than the wire.

D. Backfill:

1. Composition:
   a. Ground Hydrated Gypsum: 70 percent.
   b. Powdered Wyoming Bentonite: 20 percent.
   c. Anhydrous Sodium Sulfate: 5 percent.
2. Grain Size: 100 percent passing through a 20-mesh screen and 50 percent retained by a 100-mesh screen.
3. Mixture: Thoroughly mixed and firmly packaged around galvanic anode within cloth bag by means of adequate vibration.
4. Quantity of backfill shall be sufficient to cover surfaces of anode to a depth of 1 inch.

E. Manufactures and Products:

1. Dow; Galvomag.
2. Amax; Maxmag.

2.04 CATHODIC PROTECTION TEST STATION

A. As specified in Section 26 42 01, Pipe Bonding and Test Stations.

2.05 WIRE

A. As specified in Section 26 42 01, Pipe Bonding and Test Stations.

2.06 COUPONS

A. General: Conform to applicable requirements of ANSI/NACE RP0104.

B. Material: Coupon material to match pipe material.

C. Shape and Size: Cylindrical; 1.55 square inches (10 square centimeters) exposed metal.

D. Manufacturer and Product: MC Miller; IR-Free Coupon COU100 Series for carbon steel pipe or COU200 Series for ductile iron pipe.

2.07 REFERENCE CELLS

A. General: Shall be copper-copper sulfate in composition and designed for direct bury application in dry and wet soils.

B. Design Life: Shall have a minimum design life of 20 years.

C. Manufacturer and Product: Borin Stelth 2 Buried and Concrete Reference Electrode.

2.08 ANCILLARY MATERIALS

A. Compression Connectors:

1. For in-line, tap, and multisplice compression connectors furnish "C" taps made of conductive wrought copper, sized to fit wires being spliced.
2. Manufacturer and Product: Burndy; Type YC.

B. Wire Connectors: One-piece, tin-plated crimp-on lug connector as manufactured by Burndy Co. or Thomas and Betts.

C. Splicing Tape: Linerless rubber high-voltage splicing tape suitable for moist and wet environments; Scotch 130C and Scotch 88, as manufactured by 3M Products.

D. Shunts: 0.01-ohm Holloway Type RS.

E. Earthfill: Native soil free of roots and other organic matter, ashes, cinders, trash, debris, and rocks.

2.09 THERMITE WELD MATERIALS

A. General:

1. Thermite wire sleeves, welders, and weld cartridges according to manufacturer's recommendations for each wire size, pipe or fitting size, and material.
2. Welding materials and equipment shall be the product of a single manufacturer. Interchanging materials of different manufacturers will not be acceptable.

B. Molds: Graphite. Ceramic "One-Shot" molds are not acceptable.

C. Cartridges:

1. Cast-iron thermite weld cartridges for cast and ductile iron pipe and fittings.
2. Maximum Cartridge Size:
   a. 25 grams for steel material.
   b. 32 grams for cast and ductile iron materials.

D. Welding Materials Manufacturers:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

E. Thermite Weld Caps:

1. Prefabricated weld cap with coating and suitable primer.
2. Handy Cap II with Royston Primer 747, as manufactured by Royston Laboratories, Inc.

2.10 COATING REPAIR MATERIAL FOR PIPE AND FITTINGS

A. As recommended by pipe or fitting coating manufacturer for spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

B. Material: 100 percent solids epoxy that cures in submerged or buried conditions.

C. Manufacturers and Products:

1. Carboline, St. Louis, MO; Carboguard A-788 Splash Zone Mastic.
2. Raven Linings, Tulsa, OK; Aquatapoxy A-7.

PART 3 EXECUTION

3.01 GENERAL

A. Construct galvanic anode cathodic protection system on buried steel pipe, and ductile iron and cast iron pipe and appurtenances.

B. All materials and equipment associated with joint bonding, test stations, isolating joints, and casing isolators as shown and specified herein shall be furnished and installed by the Contractor. Any changes in design or method of installation of an item as specified shall be reviewed by the Owner.

C. Whenever the requirements of the Specifications or Drawings exceed those of the codes or manufacturer's instructions, the requirements of the Specifications or Drawings shall prevail. Where a larger size or better grade of material or a higher standard of workmanship is required, the most stringent requirement shall apply.

D. Conform to NFPA 70.

3.02 STORAGE AND HANDLING

A. Store all prepackaged anodes, anode backfill, and test stations off the ground and kept dry at all times.

B. Protect materials against weather, condensation, and mechanical damage. Immediately remove from site all damaged anodes.

C. Anode backfill material that has become wet will not be acceptable.

3.03 GALVANIC ANODE INSTALLATION

A. General:

1. Install galvanic anodes as shown on Drawings.
2. Provide minimum anode spacing of 2 feet from other unprotected pipelines.
3. Install anodes at intervals as shown on Drawings.
4. Splice anode lead wires to anode header cable as shown on Drawings.
5. Thoroughly compact earthfill around each anode to a point 1 foot above anode. Stop backfill below grade to allow for placing of topsoil, when required.
6. Bury anode wires a minimum of 24 inches below finish grade.

7. All galvanic anode groundbeds to be connected to the pipeline through a test station. Direct connection to the pipeline will not be permitted.

3.04 WIRE CONNECTIONS TO PIPE

A. Make electrical connection of copper wire to steel, ductile, and cast iron surfaces using thermite weld method. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation as recommended by manufacturer. Assure pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.

B. Before connection is made, clean surface to bare metal by making a 2-inch by 2-inch window in coating, and then filing or grinding surface to produce a bright metal finish. Grinding shall be with a vitrified type grinding wheel; use of resin, rubber, or shellac impregnated type grinding wheels is not acceptable. Prepared metal surface shall be dry.

C. Install wire sleeves on the ends of the wires before welding to metal surface. Perform thermite welding in strict accordance with manufacturer's written instructions. After weld connection has cooled, remove slag and physically test wire connection by tapping with a hammer; remove and replace defective connections.

D. Install prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations. Repair

damage to pipe lining in accordance with lining applicator's recommendations.

3.05 WIRE INSULATION REPAIR

A. Repair splices or damage to wire insulation by spirally wrapping (50 percent overlay, minimum) with two coats of splicing tape and two layers of vinyl electrical tape. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder. Splices shall be approved by Engineer.

3.06 TEST STATION INSTALLATION

A. See Section 26 42 01, Pipe Bonding and Test Stations.

3.07 FIELD TESTING

A. See Section 26 42 01, Pipe Bonding and Test Stations.

END OF SECTION

SECTION 26 43 00
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. Department of Defense: MIL-STD-220C, Test Method Standard – Method of Insertion Loss Measurement.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
   b. C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
   c. C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 497A, Standard for Secondary Protectors for Communications Circuits.
   b. 1283, Standard for Electromagnetic Interference Filters.
   c. 1449, Standard for Surge Protective Devices.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data on each suppressor type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.
2. Electrical single-line diagram showing location of each SPD.
3. Manufacturer's UL certified test data and nameplate data for each surge protective device (SPD).

1.03 QUALITY ASSURANCE

A. UL Compliance and Labeling:

1. SPDs for Power and Signal Circuits: Comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units listed and labeled by UL.
2. SPDs for Telephone Circuit Protection: Comply with UL 497A.

B. ANSI Compliance: Use SPD devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Eaton, SPD Series.

B. General Electric, Tranquell.

C. Square D, Surelogic.

D. Advanced Protection Technologies, Inc.

E. CITEL, MDS Series.

2.02 GENERAL

A. Unless indicated otherwise, provide direct bus-connected and factory-installed SPDs inside distribution equipment.

B. SPD Operating Conditions: Capable of performing at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.

C. Connect SPDs through a fused switch or circuit breaker as selected by manufacturer. Provide overcurrent protection to allow full surge handling capabilities and afford safety protection from thermal overloads and short circuits.

D. SPD Short Circuit Current Rating (SCCR): No less than the SCCR of distribution equipment.

E. Design SPD devices to protect all modes (L-L, L-N, L-G, N-G) of electrical system being used.

F. Power Filter: Include a high-frequency extended range power filter for each SPD complimentary listed to UL 1283 as an electromagnetic interference filter.

G. Provide SPDs with the following monitoring and diagnostics:

1. LED-type indication lights to show normal and failed status of each protected phase.
2. Surge event counter.
3. Form C dry contact which operates when unit fails.

H. Provide UL Type 2 SPDs.

I. EMI/RFI Noise Suppression: -50dB attenuation at 100 kHz, tested per MIL-STD 220C.

J. Voltage Protection Rating (VPR):

Voltage Rating	L-N	N-G	L-G	L-L
208Y/120	700	700	700	1200
480Y/277	1200	1200	1200	1800
120/240 3-wire	700	700	700	1200
240 Δ	--	--	1000	1000
480 Δ	--	--	1800	1800

2.03 SERVICE ENTRANCE AND DISTRIBUTION SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.

B. Surge Current Capacity:

1. Service Entrance:
   a. 200kA per phase.
   b. 100kA per mode.
2. Distribution:
   a. 120kA per phase.
   b. 60kA per mode.

C. Maximum Continuous Operating Voltage (MCOV): Not less than 115 percent of nominal system voltage.

D. Nominal Discharge Current (I_N): 20kA.

2.04 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category B.

B. Surge Current Capacity:

1. Distribution: 120kA per phase; 60kA per mode.
2. Branch: 80kA per phase; 40kA per mode.

C. Maximum Continuous Operating Voltage (MCOV): Not less than 125 percent of the nominal system voltage.

D. Nominal Discharge Current (I_N): 10kA.

2.05 PAIRED CABLE DATA LINE INTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Use bi-polar 1,500-watt silicon avalanche diodes between protected conductor and earth ground.

C. Provide units with a maximum single impulse current rating of 80 amperes (10 by 1,000 microsecond-waveform).

D. Breakdown voltage shall not exceed 36 volts.

2.06 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Design Requirements: A hybrid design with a minimum of three stages, using solid-state components and operating bi-directionally.

C. Meet or exceed the following criteria:

1. Maximum single impulse current rating of 10,000 amperes (8 by 20 microsecond-waveform).
2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform); 2,000 occurrences.
3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Provide SPDs when indicated on Drawings or in the equipment specifications.

B. Provide factory-installed SPDs as integral components to new switchgear, switchboards, motor control centers, panelboards and transfer switches. Externally mounted SPDs are not acceptable for new distribution equipment.

C. Externally mounted SPDs are acceptable for SPDs added to existing equipment as described below.

D. Electronic Equipment Paired Cable Conductors: Install data line suppressors at the low voltage input and output of each piece of equipment, including telephone cable entrance.

1. Use secondary protectors on lines that do not exit the structure.
2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install suppressors according to manufacturer's recommendations.

B. Install suppressors directly to the cabinet which houses the circuit to be protected so that the suppressor leads are straight and short, with conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

C. Provide connecting wires as short as possible with gently twisted conductors, tied together, to prevent separation.

1. Maximum Length: 24 inches.

D. Field Installed Conductors: As specified for building wire, not smaller than 8 AWG and not larger than 4 AWG. Provide device leads not longer than the maximum length recommended by manufacturer, unless specifically reviewed and approved by manufacturer.

E. Provide dedicated disconnecting means for SPD devices installed at main service entrance location, switchgear, and motor control centers. Provide dedicated 30- to 60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPD devices. Provide circuit breakers with interrupting capacity equal to that specified for other breakers at that location.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick.
   e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
   f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   g. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
   i. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
2. American Wood Protection Association (AWPA): M6, Brands Used on Forest Products.
3. Canadian Standards Association (CSA).
4. Certified Ballast Manufacturer (CBM).
5. Federal Communications Commission (FCC).
6. Illuminating Engineering Society of North America (IESNA).
   a. HB-9, Lighting Handbook.
   b. LM-79, IES Electrical and Photometric Measurements of Solid-State Lighting Products.
   c. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.

d. RP (Recommended Practices) Series.
e. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.

7. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
8. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 6, Industrial Control and Systems: Enclosures.
9. National Energy Policy Act.
10. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
11. Rural Utilities Service (RUS): 1728F-700, Specification for Wood Poles, Stubs and Anchor Logs.
12. UL:
   a. 773, UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting - Fourth Edition; Reprint with Revisions Through and Including March 08, 2002.
   b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
   c. 924, Emergency Lighting and Power Equipment.
   d. 1598, UL Standard for Safety Luminaires.
   e. 2108, UL Standard for Safety Low Voltage Lighting Systems - First Edition; Reprint with Revisions through and Including February 24, 2014.
   f. 8750, UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products - First Edition; Reprint with Revisions Through and Including April 1, 2015.
13. U.S. Environmental Protection Agency and U.S. Department of Energy: Energy Star.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. General:
      1) Provide catalog data sheets and pictures for all products listed below.
      2) Proposed Luminaire Substitutions (Interior and Exterior): Provide an electronic photometric file in standard '.ies' file format per the Illumination Engineering Society of North America (IESNA) for any proposed luminaire substitution not identified on the project Luminaire Schedule. Obtain file from the

luminaire manufacturer or approved independent photometric testing laboratory. Include the proposed substitute luminaire with all options identified on the project Luminaire Schedule.

b. Interior Luminaires:
   1) Catalog data sheets with pictures.
   2) Luminaire material, finish, dimensions, and metal gauge.
   3) Lens material, pattern, and thickness.
   4) Candle power distribution curves in two or more planes.
   5) Candle power chart 0 degree to 90 degrees.
   6) Lumen output chart.
   7) Average maximum brightness data in foot lamberts.
   8) Coefficients of utilization for zonal cavity calculations.
   9) Mounting or suspension details.
   10) Heat loss data.

c. Exterior Luminaires:
   1) Catalog data sheets with pictures. Luminaire material, finish, dimensions, and metal gauge.
   2) Lens material, pattern, and thickness.
   3) Filters.
   4) IESNA lighting classification (BUG rating).
   5) Isolux diagram.
   6) Lighting distribution data and lighting distribution classification type as defined in IESNA HB 9.
   7) Fastening details to wall, pendant, or pole.
   8) Ballast type, location, and method of fastening.
   9) For light poles, submit catalog sheet, wind loading, pole deflection with fixture attached, total weight, all accessories, complete dimensions, and finish.
   10) For concrete poles, include section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes, initial prestressing steel tension, and concrete strengths at release and at 28 days.
   11) Brackets and supports.
   12) Pole foundations.

d. LED Source Systems:
   1) General:
      a) IESNA LM-80 test reports.
      b) IESNA TM-21 ratings.
      c) Operating temperature range. Data sheet (chart/graph) describing life as a function of temperature.
      d) Warranty: Light engine and driver.
      e) Rated life.
      f) Surge protection.

g) Thermal control device, heat sink.
h) Enclosure and wiring information.
i) Operating voltage range.

2) Electronic Module/Light Engine:
a) Correlated Color Temperature (CCT).
b) Color Rendering Index (CRI).

3) Drivers:
a) Input Current Total Harmonic Distortion.
b) Power factor.
c) Sound rating.
d) Dimming system information.

e. Time Switches:
1) Wiring diagram.
2) Contact ratings.
3) Functional features.
4) Programmable capabilities.
5) Enclosure type, dimensions.

f. Lighting Contactor:
1) Type (mechanically or electrically held).
2) Enclosure.
3) Contact ratings and configuration.
4) Coil operating voltage.

g. Photoelectric Switches (Photocells):
1) Voltage.
2) Power consumption.
3) Load capacity (watts).
4) Contact ratings and configuration.
5) Time delay.
6) Light operating level controls.
7) Enclosure type and dimensions.
8) Mounting type.
9) Temperature range.
10) Features and options.

h. Wall box dimmers.
i. Dimming systems.
j. Occupancy Sensors:
1) Type.
2) Switching capacity.
3) Coverage.
4) Time delay AUTO/OFF adjustment.

k. Outdoor Motion Sensors.
l. Emergency Shunt Relay.
m. Standby lighting panel.
n. Luminaire lowering device.

o. Landscape Lighting:
   1) Luminaires.
   2) Controls.
   3) Transformers.
   4) Wiring.
p. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's printed installation instructions.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by UL in conformance with those standards and with an applied UL listing mark.

B. Standard Products:

1. Provide materials and equipment of manufacturers regularly engaged in the production of products specified in this section and that are of equal material, design, and workmanship.
2. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to Bid opening in similar applications under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
3. Material and Equipment Manufacturing Date: Do not use products manufactured more than 3 years prior to date of delivery to Site.

C. Preinstallation Meeting for low voltage lighting control systems:

1. Occupancy Sensors: Arrange preinstallation meeting with manufacturer's factory authorized representative at Owner's facility, to verify placement of sensors and installation criteria.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Concrete Poles:

1. Do not store poles on ground.
2. Support poles so they are at least 1 foot above ground level and growing vegetation.
3. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

B. Aluminum or Steel Poles:

1. Provide manufacturer's standard protection for the finish during shipment and installation. At minimum, spirally wrap each pole shaft with protective paper secured with tape, and ship small parts in boxes.
2. Do not store poles on ground.
3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following luminaires:

Item	Quantity
Luminaire	One complete set(s) per unit

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.

B. Provide luminaires and components tested, listed, and labeled by UL, or other approved testing agency.

C. Provide luminaires with Illumination Engineering Society of North America (IESNA) formatted photometric files, ".ies" format, certified by the luminaire manufacturer for use with lighting software.

D. Luminaire Labels:

1. External label per ANSI C136.15.
2. Internal label per ANSI C136.22.

E. Provide luminaires rated by the manufacturer to start and operate to their full lumen capacity for rated life of the luminaire at the minimum low and maximum high ambient temperatures as defined in the Contract Documents at their installation location.

F. Feed-through type, or separate junction box.

G. Wire Leads: Minimum 18 AWG.

H. Component Access: Accessible and replaceable without removing luminaire from ceiling.

I. Soffit Installations (Interior or Exterior Damp Locations):

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.

J. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. When factory-installed photocells are provided, entire assembly shall have UL label.

K. Illuminated Exit Signs:

1. Body: As scheduled.
2. Face: Translucent.
   a. Letters:
      1) 6-inch high by 3/4-inch stroke.
      2) Color: As scheduled.
3. Mounting: As scheduled.
4. Directional Arrows: As indicated on Drawings.

L. Emergency Lighting Units:

1. Power Pack: Self-contained, transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.

6. Emergency Self-Diagnostic System:
   a. Solid state device with LED display and audible alarm.
   b. Automatic and manual test unit.
   c. Test for malfunction of lamps, battery, and charger board.
   d. Manufacturer: Lithonia.

M. Hazardous Classified Areas:

1. UL Labeled: As indicated in the Luminaire Schedule.
2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

2.02 LED SOURCE SYSTEMS

A. General:

1. Provide IESNA LM-80 test reports.
2. Provide Energy Star compliance for solid state luminaires.
3. Listed To: UL 8750 Standard for Safety for Light Emitting Diode (LED) Equipment for use in Lighting Products.
4. Provide RoHS compliant LED light source(s) and driver(s).
5. Rated operating temperature range as indicated on the Luminaire Schedule.
6. Warranty: 5 years minimum.

B. Electronic Module/Light Engine:

1. Mount all components to a single plate and factory prewired with quick-disconnect plugs.
2. Include a driver, thermal control device, thermal protector device, and surge protector device.
   a. Provide surge protector tested in accordance with IEEE/ANSI C62.41.2 to Category C Low.
3. Provide LEDs mounted to a metal-core circuit board and aluminum heat sink for optimal thermal management and long life.
4. Light Engine Rating per TM-21: 100,000 at 25 degrees C, L70.
5. Correlated Color Temperature (CCT): As indicated on the Luminaire Schedule.
6. Color Rendering Index (CRI): Minimum of 80.

C. Drivers:

1. Expected life of 100,000 hours at 25 degrees C.
2. Provide drivers mounted in an all metal can.
3. Operating Voltage Range: 50/60-Hz input source, voltage range as indicated on the Luminaire Schedule with sustained variations of plus or minus 10 percent voltage with no damage to the driver.

4. Input Current Total Harmonic Distortion: Less than 20 percent up to 50 percent of full load rating.
5. Power Factor: Greater than 0.90 for primary application up to 50 percent of full load rating.
6. Sound rating: Class A.
7. Comply with NEMA 410 for inrush current limits.
8. Dimming:
    a. Continuously dimmable from 0 percent to 100 percent.
    b. Dimming Control: 0V to 10V.
    c. Provide driver compatible with standalone dimming controls and/or dimming systems used.

2.03 LIGHTING CONTROL

A. Time Switch, Electronic Programmable Type:

1. Provide digital electronic time switch with number of channels indicated on Drawings.
2. Programming: Each channel shall be independently programmable and include:
    a. A Form C dry contact, output rated for 20 amps at 120V ac for operation on inductive, ballast, and LED driver loads.
    b. Provide channels with ON/OFF set points in a 24-hour period for each day or the week.
    c. 365-day capability.
    d. Astronomic time functionality.
    e. User-programmable daylight savings time adjustment option.
    f. Automatic daylight savings changeover.
    g. Automatic leap year compensation.
3. Time Switch Minimum Features:
    a. Selectable am/pm or 24-hour format.
    b. 1-minute time resolution.
    c. Control Inputs: Up to two control inputs capable of connection to input devices including photoelectric relays, discrete input devices, and others, for use in programming output channels.
    d. Battery backup with rechargeable batteries and 72-hour capacity.
    e. Individual manual ON/OFF override control for each channel.
4. Manufacturers:
    a. Tork.
    b. Intermatic.
    c. Paragon Electric Company.

B. Lighting Contactor:

1. Features:
   a. Electrically held contactor.
   b. Contacts Rating: As indicated on Drawings.
   c. Enclosure: NEMA 250 Type 1 enclosure conforming to NEMA ICS 6.
   d. Provide contactor with HAND-OFF-AUTOMATIC selector switch.

C. Photoelectric Switch (Photocell):

1. Automatic Solid State ON/OFF Switching Photo Control:
   a. Dry Contacts:
      1) Configuration: SPST.
      2) Rating: 1,800VA tungsten, 1,000VA inductive.
      3) Compatible with connected load device indicated on Drawings.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Mounting Type: 1/2-inch conduit entry.
4. Setting: ON at dusk and OFF at dawn.
5. Time delay feature to prevent false switching.
6. Field adjustable to control operating light levels.
7. Integral surge protection.
8. Manufacturers:
   a. Tork.
   b. Intermatic.
   c. Paragon Electric Company.

D. Photo Sensors/Controls for Daylight Harvesting Control:

1. General.
   a. Operating Temperature: 32 degrees F to 120 degrees F.
   b. Environment: Indoor dry.
   c. Illumination Sensing Levels:
      1) 10 Foot-candles to 200 Foot-candles: General interior spaces.
      2) 100 Foot-candles to 1,000 Foot-candles: Atriums, light shelves.
      3) 1,000 Foot-candles to 10,000 Foot-candles: Light wells, skylights.
   d. Output: Compatible with individual lighting load characteristics controlled.
2. Switching Control:
   a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and shall

convey changes to a control unit/power pack switching device. Switching device shall open and close load contacts based on field programmable set points.

b. Power Pack:
   1) Dry contacts rated 20A at 120/277V ac.
   2) Adjustable Time Delay: 5 seconds to 300 seconds.
   3) Set point adjustment for both on and off operation.

3. Dimming Control:
   a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and modulate electric luminaire lighting output to maintain a fixed lighting level in the space.
   b. Controller Unit:
      1) 120/277V ac input.
      2) 24V dc output to power the sensor.
   c. Sensor Output: 0V dc to 10V dc.
   d. Light level set point adjustment performed by separate hand held remote control device.

E. Wall Box Dimmers:

1. General:
   a. Modular gangable design.
   b. Solid-state circuitry.
   c. Voltage: As required on Drawings.
   d. ON/OFF switch integral to the unit. ON/OFF switch shall be independent of dimming level function.
   e. Single-pole or three-way as indicated on Drawings.
   f. Operator:
      1) Continuous adjustability throughout the dimming range.
      2) UP/DOWN buttons.
   g. Integral suppression for audible frequency and EMI/RFI.
   h. Comply with UL 1472.
2. LED System Dimmers: Certified by manufacturer to operate on dimming drivers provided with luminaires in this Project.

F. Occupancy Sensors:

1. General:
   a. Capable of operating normally with any electronic ballast and PL lamp systems.
   b. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to cycling of air conditioner or heating fans.
   c. Provide sensors with readily accessible, user adjustable controls for time delay and sensitivity.

d. Provide a bypass manual OVERRIDE ON key on each sensor to allow operation in the event of sensor failure. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. Recess bypass control to prevent tampering.

2. Sensor Technology:
   a. Passive Infrared (PIR):
      1) Provide sensors that respond to human heat and movement to detect occupants in the coverage area.
      2) Temperature compensated pyroelectric sensor.
      3) High immunity to false triggering due to RFI and EMI noise.
      4) Provide passive infrared sensors with a multiple segmented lens, in a multiple-tier configuration, with grooves-in to eliminate dust and residue buildup.
      5) Detection Range (IR Range) on Axis: 1,200 square feet.
   b. Ultrasonic:
      1) Provide sensors which respond to ultrasonic disturbances within as well as outside the line of sight to detect occupants in the coverage area.
      2) Use advanced signal processing technology to adjust the detection threshold dynamically to compensate for constantly changing levels of activity and airflow throughout the controlled space.
      3) Detection Range (IR Range) on Axis: 500 square feet to 2,000 square feet.
   c. Dual Technology:
      1) Sensors use a combination of passive infrared and ultrasonic technologies to detect occupants in coverage area.
      2) Provide technology mode selection to allow installer to configure the operation mode between dual technology, passive infrared only, or ultrasonic only functionality.
      3) Detection Range (IR Range) on Axis: 2,000 square feet.
      4) No audio dual technology units will be accepted.
3. Sensor Mounting:
   a. Ceiling:
      1) Directional Coverage: 360 degrees.
   b. Wall:
      1) Directional Coverage: 180 degrees.
   c. Corner:
      1) Coverage: 90 degrees.
   d. Switch Box:
      1) Directional Coverage: 180 degrees.
      2) Coverage Area: At desk top level up to 300 square feet and gross motion up to 1,000 square feet.

3) Switch Types:
a) Single circuit switches shall control a single switched circuit.
b) Bi-level switches shall accommodate up to two switched circuits.
4) Loads:
a) Wall box switches shall include an integral power supply.
b) Switches shall accommodate loads from 0 watt to 800 watts at 120 volts; 0 watt to 1,200 watts at 277 volts.

e. High-Bay:
1) Directional Coverage: 360 degrees.
2) Mounting Height: 12 feet to 50 feet
3) Mounting: Conduit threads.
4) Bi-level switches turn lights on when an occupant enters the coverage area and turns lights either off or to a preset dimmed level after the coverage area is vacated for a preset time delay.
5) Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.

4. Circuit Control Hardware—CU Power Packs:
a. Control Units: Able to mount through a 1/2-inch knockout in a standard electrical enclosure and be an integrated, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer shall provide power to a minimum of two sensors.
b. Relay Contact Ratings:
1) 13A, 120V ac tungsten.
2) 20A, 120V ac ballast.

5. Wiring: Control wiring between sensors and control units shall be Class II, 14 AWG, stranded, UL Classified, PVC insulated or Teflon jacketed cable approved for use in plenums, where applicable.

6. Manufacturers:
a. Unenco, Inc.
b. The Watt Stopper, Inc.

2.04 OUTDOOR MOTION SENSORS

A. Operation: Sensor shall detect movement of human body a minimum of 36 square inches in size over a distance of 6 inches or more.

B. Ratings:

1. Voltage: 120/277V ac.
2. Load: 1 amp at 24V ac/V dc to 30V ac/V dc.
3. Environmental: Weatherproof, raintight.
4. Temperature: Minus 40 degrees F to 130 degrees F.

C. Mounting:

1. 1/2-inch conduit thread.
2. Includes directional swivel knuckle.

D. Adjustable Settings:

1. Light level.
2. Time delay.

E. Directional Coverage: 270 degrees.

2.05 POLES

A. General:

1. Design for wind load as specified in Section 01 61 00, Common Product Requirements, while supporting luminaires and other appurtenances. Use effective projected areas (EPA) of luminaires and appurtenances in calculations specific to the actual products proposed on each pole.
2. Poles 40 feet and Shorter: One-piece construction.
3. Pole Height: As indicated on Luminaire Schedule.
4. Handhole:
   a. Except for wood poles, Provide oval-shaped handhole having a minimum clear opening of 2.5 inches by 5 inches.
   b. Secure cover with stainless steel captive screws.
   c. Metal Poles: Provide an internal grounding connection accessible from handhole near bottom of each pole.
5. Do not install scratched, stained, chipped, or dented poles.

B. Wood Poles:

1. Gained, bored, and roofed before treatment.
2. Treated full length with chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA).
3. Branded by manufacturer with manufacturer's mark and date of treatment, height and class of pole, wood species, preservation code, and retention. Place brand so bottom of brand or disc is 10 feet from pole butt for poles up to 50 feet long and 14 feet from butt for poles over 50 feet long.

4. Pressure Treated Wood Pole Quality: Furnish inspection report of an independent inspection agency, approved by Engineer, stating that offered products comply with AWPA M6 and RUS 1728F 700 standards. The RUS approved Quality Mark “WQC” on each pole will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

C. Concrete Poles:

1. Cross-Sectional Shape: Round or multi-sided.
2. Steel Reinforcing:
   a. Prestressed Concrete Pole Shafts: Reinforce with steel prestressing members.
   b. Design for internal longitudinal loading by either pretensioning or post-tensioning of longitudinal reinforcing members.
3. Tensioned Reinforcing:
   a. Primary Reinforcement Steel Used for a Prestressed Concrete Pole Shaft: Tension to between 60 percent and 70 percent of its ultimate strength.
   b. Design reinforcement so that when reinforcement is tensioned to 70 percent of its ultimate strength, the total resultant tensile force does not exceed the minimum section compressive strength of the concrete.
4. Coating and Sleeves for Reinforcing Members:
   a. Where minimum internal coverage cannot be maintained next to required core openings, such as handhole and wiring inlet, protect reinforcing with a vaporproof noncorrosive sleeve over the length without the 1/2-inch concrete coverage.
   b. Coat each steel reinforcing member to be post-tensioned with a nonmigrating slipper coating prior to the addition of concrete to ensure uniformity of stress throughout length of such member.
5. Strength Requirement:
   a. Naturally cured to achieve a 28-day compressive strength of 7,000 psi.
   b. Do not subject to severe temperature changes during curing period.
6. Shaft Preparation:
   a. Completed Prestressed Concrete Pole Shaft Surface:
      1) Hard, smooth, and nonporous.
      2) Resistant to soil acids, road salts, and attacks of water and frost.
      3) Clean, smooth, and free of surface voids and internal honeycombing.
   b. Install a minimum of 15 days after manufacture.

D. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: As noted in schedule.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with cap.
5. Base:
   a. Anchor bolt-mounted and machined to receive lower end of shaft.
   b. Welded joint between shaft and base.
   c. Base Cover: Cast aluminum alloy.
   d. Hardware, Except Anchor Bolts: either anodized aluminum alloy or stainless steel.
   e. Handhole.
6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
8. Pole and Bracket Finish: As noted in Luminaire Schedule

E. Steel Poles:

1. Minimum 11-gauge steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized factory finish.
2. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
3. Square poles shall be hinged.
4. Tapered tubular members, either round in cross section or polygonal.
5. Pole Markings: Approximately 3 feet to 4 feet abovegrade and include manufacturer, year of manufacture, top and bottom diameters, and length.
6. Base Covers: Structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.

2.06 POLE FOUNDATIONS

A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; at minimum, galvanize the top 12 inches of the rod.

B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 STANDBY LIGHTING PANEL

A. AC Emergency Power Supply:

1. Rating: As noted on Drawings.
2. Frequency Regulation: Plus or minus 0.5 Hz.
3. Voltage Regulation: Plus or minus 5 percent.
4. Operation:
   a. In normal operating mode, feed supply power to load and battery charger.
   b. Upon failure (loss or undervoltage) of normal supply, automatically transfer load to alternate power source provided by inverter and battery.
   c. When normal power is restored, retransfer load and battery charger to normal supply.

B. Inverter:

1. Construction: Solid state.
2. Sine Wave Output: Stepped, not causing abnormal lighting ballast heat rise.
3. Self-protected from short circuits and overloads.
4. Switch Type: Mechanical, capable of transferring from normal to emergency in less than 30 milliseconds.

C. Batteries:

1. Type: Lead antimony (lead acid).
2. Sized for 90 minutes operation with a discharge to not less than 87.5 percent of nominal battery voltage.

D. Battery Charger:

1. Type: Solid state SCR.
2. Recharge Time: 12 hours, following a discharge to 87.5 percent of nominal battery voltage.

E. Indicators and Controls:

1. Output voltmeter and output current meter.
2. Charge light indicator.
3. Normal power on light.
4. Test switch to simulate a power failure.
5. Charge alarm light.
6. Battery voltmeter.
7. Battery ammeter.

F. Enclosure:

1. Type: Steel, wall mounted.
2. Finish: Red baked enamel.

G. Manufacturers:

1. Holophane Corp.
2. Siltron Emergency Systems.
3. Chloride.

2.08 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof, of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.

2.09 LANDSCAPE LIGHTING

A. Materials:

1. Fixtures shall meet UL standards and be suitable for outdoor installation.
2. Lighting type: LED.
3. Wire Type:
   a. Low Voltage: 12-gauge, two-wire, UV-rated coating.
   b. Line Voltage: 12 AWG, THHN.
   c. UL approved.
4. Wire Fastening: Hardware shall be composed of corrosion resistant materials.
5. Transformers:
   a. UL approved in addition to meeting NEC codes.
   b. Overcurrent protection in accordance with NEC.
6. Conduit: In accordance with Section 26 05 33, Raceway and Boxes.
7. Pull Boxes and Junction Boxes: Suitable for outdoor installation per Section 26 05 33, Raceway and Boxes.

2.10 EQUIPMENT IDENTIFICATION

A. Manufacturer's Nameplate: Provide each item of equipment with a nameplate bearing manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Provide clear markings located to be readily visible to service personnel.

2.11 FACTORY FINISH

A. Provide electrical equipment with factory-applied painting systems that, at minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation and meeting specified seismic requirements.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
   a. Coordinate mounting, fastening, and environmental conditions with Section 26 05 02, Basic Electrical Requirements.
   b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
   a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
   b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
   c. Provide twin-stem hangers on single luminaires.
   d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.

4. Pole Mounted:
    a. Provide cast-in-place or precast concrete base as indicated on Drawings.
    b. Provide branch circuit in-line fuses in pole base handhole.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

D. Finished Areas:

1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
    a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
    b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
    a. Provide wiring of temperature rating required by luminaire.
    b. Provide flexible steel conduit.
7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
    a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
    b. Select chain or wire with tensile strength and method of fastening to structure adequate to support luminaire weight.
    c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

F. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LIGHTING CONTROL

A. Outdoor Luminaires: Photocells switch lights ON at dusk and OFF at dawn.

B. Dimming Systems:

1. Install in accordance with manufacturer's recommendations.
2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

C. Occupancy Sensors: Locate and aim sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer's recommendations. Provide 90 percent to 100 percent room coverage to accommodate all occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown on Drawings are diagrammatic and only indicate which rooms are to be provided with sensors. Provide additional sensors if required to properly and completely cover respective room.

3.03 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.04 POLES

A. Electrical Installations: Conform to IEEE C2 and requirements specified herein.

B. Pole Setting:

1. Depth: As indicated on Drawings or footing detail.
2. Install poles in straight runs in a straight line.

C. Wood Poles: Provide pole holes at least as large at the top as at the bottom and large enough to provide 4 inches of clearance between pole and side of hole.

1. Setting Depth:

Length of Pole (feet)	Setting in Soil (feet)
20	5.0
25	5.5
30	5.5
35	6.0
40	6.0
45	6.5
50	7.0
55	7.5
60	8.0

2. Soil Setting: Depths shall apply where pole holes are in soil, sand, or gravel or any combination of these.
3. Setting on Sloping Ground: On sloping ground, measure depth of hole from low side of hole.
4. Backfill: Tamp pole backfill for the full depth of hole and mound excess fill around pole.
5. Dig holes large enough to permit the proper use of tampers to the full depth of the hole.
6. Place backfill in the hole in 6-inch maximum layers and thoroughly tamp.
7. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

D. Concrete Poles: Install according to pole manufacturer's instructions.

E. Aluminum and Steel Poles: Install according to pole manufacturer's instructions.

1. Provide cast-in-place or precast concrete base, as shown on Drawings.
2. Provide branch circuit in-line fuses in pole base handhole.

F. Photocell Switch Aiming: Mount and aim switch according to manufacturer's recommendations.

G. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.05 LANDSCAPE LIGHTING

A. General: Electrical work and installation shall be in accordance with Article 411 of the NEC.

B. Installation:

1. Aboveground:
   a. Locate wire, hardware, and fixtures so as to allow for “normal” unobstructed plant growth with attention paid to the following:
      1) Hardware or fixtures should not be mounted in such a way that wire needs to be routed through a tree branch or trunk union.
      2) Branches or trunks should not be encircled with wire or other hardware.
      3) Maintain 10 inches minimum between new and existing installations of tree hardware.
   b. Protect wire by PVC conduit or water-resistant flexible conduit to a minimum of 8 feet abovegrade.
   c. Make connections in approved junction boxes.
   d. Secure conduit to tree with appropriate approved clips and hardware.
      1) Wire is to be fastened only with galvanized wire staples which have standoff nubs.
      2) Do not drive staples into tree past the standoff nubs to avoid pinching wire. Leave wire loose to allow for tree sway, tree growth, and wire expansion and contraction.
   e. Leave 10-inch slack or service loop at each end junction or fixture to allow:
      1) Wire contraction.
      2) Servicing.
      3) Relocation.
2. Belowgrade Wiring:
   a. Excavating and Backfill:
      1) Excavate trenches for electrical conduit and wiring of sufficient width to permit proper handling and installation of pipe and fittings.

2) Trenches containing conduit for line voltage wiring must have a minimum cover of at least 15 inches wherever possible and 18 inches minimum in vehicle areas.
3) Trenches containing conduit for low voltage wiring must have a minimum cover of at least 6 inches wherever possible.
4) Compact backfill up to original grade level to 90 percent of the modified Proctor density.

b. Pulling:
1) Size pull boxes in accordance with Section 26 05 33, Raceway and Boxes.
2) Keep interior of conduit free from dirt and debris.

c. Underground Conduit: Install per Section 26 05 33, Raceway and Boxes.

d. Pull Boxes and Junction Boxes:
1) Install in accordance with Section 26 05 33, Raceway and Boxes.
2) Boxes shall remain accessible at all times.

3.06 FIELD FINISHES

A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Paint as specified in Section 09 90 00, Painting and Coating.

3.07 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 91 14, Equipment Testing and Facility Startup.

3.08 MANUFACTURER'S SERVICES

A. Occupancy Sensors: Furnish manufacturer's representative at Job Site in accordance with Section 01 43 33, Manufacturers' Field Services, to inspect installation, test unit, and put into service.

3.09 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective luminaires at time of Substantial Completion.

END OF SECTION