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SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL
BASED ON DFD MASTER ELECTRICAL SPEC DATED 12/26/23

PART 1 - GENERAL

The electrical work included in all other divisions is the responsibility of the contractor performing the division 26 work unless noted otherwise.

PROJECT OVERVIEW

Major electrical work involved on the project includes: Coordinating with local utility for installation of new 200A 208V 3phase electrical service including installation of all branch circuit panelboard and wiring. Furnishing and installation of new interior LED lighting and controls and exterior wall-mounted LED lighting. Furnishing and installation of new access controls devices including card readers, door contacts, request to exit devices, electric strikes, and required door control panel.

SCOPE

The work under this section includes basic electrical requirements, which are applicable to all Division 26 sections. This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections. Included are the following topics:

PART 1 - GENERAL

- Project Overview
- Scope
- Related Work
- Reference Standards
- Regulatory Requirements
- Quality Assurance
- Protection of Finished Surfaces
- Approved Electrical Testing Laboratories
- Sleeves and Openings
- Sealing and Fire Stopping
- State and/or User Agency Furnished Equipment
- Work by State and/or User Agency
- Provisions for Future Work
- Intent
- Omissions
- Submittals
- Project/Site Conditions
- Work Sequence and Scheduling
- Work by Other Trades
- Offsite Storage
- Certificates and Inspections
- Operating and Maintenance Data
- Record Drawings

PART 2 - PRODUCTS

- Identification
- Sealing and Fire Stopping

PART 3 - EXECUTION

- Excavation and Backfill
- Concrete Work
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Sleeves and Openings
- Sealing and Fire Stopping
- Housekeeping and Clean Up
- Agency Training

1
2 **RELATED WORK**

3 Applicable provisions of Division 1 govern work under this Section.

4
5 Section 01 91 01 or 01 91 02 – Commissioning Process

6 Section 07 84 00 – Fire Stopping

7
8 **REFERENCE STANDARDS**

9 Abbreviations of standards organizations referenced in this and other sections are as follows:

10
11 ANSI American National Standards Institute
12 ASTM American Society for Testing and Materials
13 EPA Environmental Protection Agency
14 ETL Electrical Testing Laboratories, Inc.
15 IEEE Institute of Electrical and Electronics Engineers
16 IES Illuminating Engineering Society
17 ISA Instrument Society of America
18 NBS National Bureau of Standards
19 NEC National Electric Code
20 NEMA National Electrical Manufacturers Association
21 NESC National Electrical Safety Code
22 NFPA National Fire Protection Association
23 NRTL Nationally Recognized Testing Laboratory
24 UL Underwriters Laboratories Inc.
25 DSPS Wisconsin Department of Safety and Professional Services

26
27 **REGULATORY REQUIREMENTS**

28 All work and materials are to conform in every detail to applicable rules and requirements of the Wisconsin
29 State Electrical Code (SPS 316), the National Electrical Code (NFPA 70), other applicable National Fire
30 Protection Association codes, the National Electrical Safety Code, and present manufacturing standards
31 (including NEMA).

32
33 All Division 26 work shall be done under the direction of a currently licensed State of Wisconsin Master
34 Electrician.

35
36 All Division 26 work shall comply with SPS 101.862 and SPS 305.40 for electrical wiring integral with pre-
37 manufactured structures.

38
39 **QUALITY ASSURANCE**

40 Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or
41 engineering parameters from those indicated on the contract documents, the contractor is responsible for all
42 costs involved in integrating the equipment or accessories into the system and the assigned space, and for
43 obtaining the performance from the system into which these items are placed.

44
45 Manufacturer references used herein are intended to establish a level of quality and performance requirements
46 unless more explicit restrictions are stated to apply.

47
48 All materials, shall be listed by and shall bear the label of an approved Nationally Recognized Testing
49 Laboratory (NRTL) as identified by the United States Occupational Safety and Health Administration
50 (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program. If none of the approved
51 electrical testing laboratories has published standards for a particular item, then other national independent
52 testing standards, if available, applicable, and approved by DFD, shall apply and such items shall bear those
53 labels. Where one of the approved electrical testing laboratories has an applicable system listing and label,
54 the entire system, shall be so labeled.

55
56 **PROTECTION OF FINISHED SURFACES**

57 Furnish one can of touch-up paint for each different color factory finish furnished by the Contractor. Deliver
58 touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

59
60 **APPROVED ELECTRICAL TESTING LABORATORIES**

61 The following laboratories are approved for providing electrical product safety testing, listing and labeling
62 services as required in these specifications:

1 A Nationally Recognized Testing Laboratory (NRTL) as identified by the United States Occupational Safety
2 and Health Administration (OSHA), per the OSHA Nationally Recognized Testing Laboratory Program.

3
4 **SLEEVES AND OPENINGS**

5 Refer to Division 1, General Requirements, Sleeves and Openings.

6
7 **SEALING AND FIRE STOPPING**

8 Sealing and fire stopping of sleeves/openings between conduits, cable trays, wireways, troughs, cablebus,
9 busduct, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose
10 work penetrates the opening. Provide all fire stopping of fire rated penetrations and sealing of smoke rated
11 penetrations in compliance with section 07 84 00 Fire Stopping.

12
13 **WORK BY STATE AND/OR USER AGENCY**

14 Electrical testing not described in these contract documents will be by the DFD under separate contract.

15
16 **INTENT**

17 The Contractor shall furnish and install all the necessary materials, apparatus, and devices to complete the
18 electrical equipment and systems installation herein specified, except such parts as are specifically exempted
19 herein.

20
21 If an item is either called for in the specifications or shown on the plans, it shall be considered sufficient for
22 the inclusion of said item in this contract. If a conflict exists within the Specifications or exists within the
23 Drawings, the Contractor shall furnish the item, system, or workmanship, which is the highest quality, largest,
24 or most closely fits the DFD's intent (as determined by the DFD Project Manager). Refer to the General
25 Conditions of the Contract for further clarification.

26
27 It must be understood that the details and drawings are diagrammatic. The Contractor shall verify all
28 dimensions at the site and be responsible for their accuracy.

29
30 All sizes as given are minimum except as noted.

31
32 Materials and labor shall be new (unless noted or stated otherwise), first class, and workmanlike, and shall
33 be subject at all times to the DFD's and/or A/E's inspections, tests and approval from the commencement
34 until the acceptance of the completed work.

35
36 Whenever a particular manufacturer's product is named, it is intended to establish a level of quality and
37 performance requirements unless more explicit restrictions are stated to apply.

38
39 **OMISSIONS**

40 No later than ten (10) days before bid opening, the Contractor shall call the attention of the DFD to any
41 materials or apparatus the Contractor believes to be inadequate and to any necessary items of work omitted.

42
43 **SUBMITTALS**

44 Submit for all equipment and systems as indicated in the respective specification sections, marking each
45 submittal with that specification section number. Mark general catalog sheets and drawings to indicate
46 specific items being submitted and proper identification of equipment by name and/or number, as indicated
47 in the contract documents. Failure to do this may result in the submittal(s) being returned to the Contractor
48 for correction and resubmission. Failing to follow these instructions does not relieve the Contractor from the
49 requirement of meeting the project schedule.

50
51 On request from the DFD, the successful bidder shall furnish additional drawings, illustrations, catalog data,
52 performance characteristics, etc.

53
54 Submittals shall be grouped to include complete submittals of related systems, products, and accessories in
55 a single submittal. Mark dimensions and values in units to match those specified. Include wiring diagrams
56 of electrically powered equipment.

57
58 The submittals must be approved before fabrication is authorized.

59
60 Submit sufficient quantities of submittals to allow the following distribution:

61	Operating and Maintenance Manuals	2 copies
62	User agency	1 copy
63	A/E	1 copy

PROJECT/SITE CONDITIONS

Install Work in locations shown on drawings, unless prevented by project conditions.

Prepare drawings showing proposed rearrangement of work to meet project conditions, including changes to work specified in other sections. Obtain permission of DFD before proceeding.

Tools, materials and equipment shall be confined to areas designated by the DFD and user agency.

WORK SEQUENCE AND SCHEDULING

Install work in phases to accommodate user agency's occupancy requirements. During the construction period coordinate electrical schedule and operations with DFD's Construction Representative.

WORK BY OTHER TRADES

Every attempt has been made to indicate in this trade's specifications and drawings all work required of this Contractor. However, there may be additional specific paragraphs in other trade specifications and addenda, and additional notes on drawings for other trades which pertain to this trade's work, and thus those additional requirements are hereby made a part of these specifications and drawings.

Electrical details on drawings for equipment to be provided by others are based on preliminary design data only. This Contractor shall lay out the electrical work and shall be responsible for its correctness to match equipment actually provided by others.

OFFSITE STORAGE

Prior approval by DFD and the A/E will be needed. The contractor shall submit Storage Agreement Form DOA-4528 to DFD for consideration of off-site materials storage. In general, building wire, conduit, fittings and similar rough-in material will not be accepted for off-site storage. No material will be accepted for off-site storage unless shop drawings for the material have been approved.

CERTIFICATES AND INSPECTIONS

Obtain and pay for all required installation inspections, except those provided by the DFD, in accordance with the Wisconsin Administrative Code. Deliver originals of these certificates to the DFD's Project Representative.

The Electrical Contractor is responsible for coordination of DFD electrical inspections. Prior to the start of significant on-site electrical work, the contractor shall schedule a pre-installation meeting with the DFD Electrical Inspector to discuss the inspection requirements and review the contract requirements (also see Article 15 of the General Conditions). The Electrical Contractor shall be present when the DFD Electrical Inspector conducts the electrical inspections.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Manufacturer's wiring diagrams for electrically powered equipment.
2. All required passwords required to gain local access to equipment and controllers.
3. Manufacturer's product data for lighting and controls.
4. Manufacturer's product data for access control components.

RECORD DRAWINGS

The Contractor shall maintain at least one copy each of the specifications and drawings on the job site at all times.

The DFD will provide the Contractor with a suitable set of contract drawings on which daily records of changes and deviations from contract shall be recorded. Dimensions and elevations on the record drawings shall locate all buried or concealed piping, conduit, or similar items.

1 The daily record of changes shall be the responsibility of Contractor's field superintendent. No arbitrary
2 mark-ups will be permitted.

3
4 At completion of the project, the Contractor shall submit the marked-up record drawings to the
5 Architect/Engineer prior to final payment.

6 7 **PART 2 - PRODUCTS**

8 9 **IDENTIFICATION**

10 See Electrical section 26 05 53 – Identification for Electrical Systems.

11 12 **SEALING AND FIRE STOPPING**

13 **FIRE AND/OR SMOKE RATED PENETRATIONS:**

14 Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with
15 section 07 84 00 “Fire Stopping”.

16 17 18 **NON-RATED PENETRATIONS:**

19 **Conduit and Cable Tray Penetrations Above Grade:**

20 At through-wall conduit and cable tray penetrations of non-rated interior and exterior walls, and floors, use
21 urethane caulk in annular space between conduit and sleeve, or the core drilled opening.

22 23 **PART 3 - EXECUTION**

24 25 **EXCAVATION AND BACKFILL**

26 Perform all excavation and backfill work to accomplish indicated electrical systems installation unless noted
27 otherwise.

28 29 **CONCRETE WORK**

30 The Division 3 Contractor will perform all cast-in-place concrete unless noted otherwise elsewhere. Provide
31 all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to
32 form concrete for the support of electrical equipment.

33 34 **CUTTING AND PATCHING**

35 Refer to Division 1, General Requirements, Cutting and Patching.

36 37 **BUILDING ACCESS**

38 Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the
39 building access was not previously arranged and must be provided by this contractor, restore any opening to
40 its original condition after the apparatus has been brought into the building.

41 42 **EQUIPMENT ACCESS**

43 Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance.
44 Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making
45 sure that access is available for all equipment and specialties. Where access is required in plaster or drywall
46 walls or ceilings, furnish the access doors to the General Contractor and reimburse the General Contractor
47 for installation of those access doors.

48 49 **COORDINATION**

50 The Contractor shall cooperate with other trades and DFD in locating work in a proper manner. Should it be
51 necessary to raise or lower or move longitudinally any part of the electrical work to better fit the general
52 installation, such work shall be done at no extra cost to the DFD, provided such decision is reached prior to
53 actual installation. The Contractor shall check location of electrical outlets with respect to other installations
54 before installing.

55
56 The Contractor shall verify that all devices are compatible for the surfaces on which they will be used. This
57 includes, but is not limited to light fixtures, panelboards, devices, etc. and recessed or semi-recessed heating
58 units installed in/on architectural surfaces.

59
60 Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated
61 and that interferes with other contractor's work shall be removed or relocated at the installing contractor's
62 expense.

63

1 Coordinate all equipment requirements with the various contractors and the Owner. Review the complete
2 set of drawings and specifications to determine the extent of wiring, starters, devices, etc., required.
3 Coordinate the available fault current- equipment including control panels and internal components shall be
4 rated to interrupt the available fault current.
5

6 7 **SLEEVES AND OPENINGS**

8 Conduit penetrations in new poured concrete horizontal construction requiring F and T rating: Form opening
9 using hole form or core drill opening. Alternatively provide cast in place fire stopping devices/sleeves.

10
11 Conduit penetrations in new poured concrete horizontal construction requiring F rating but no T rating: Same
12 as conduit penetrations in new poured concrete construction requiring F and T ratings except that schedule
13 40 steel pipe sleeves may also be used.

14
15 Conduit penetrations in new poured concrete horizontal construction that do not require F or T ratings:
16 Provide schedule 40 steel pipe sleeve, form opening using hole form or core drill opening.

17
18 Where penetrating conduit weight is supported by floor, provide manufactured product or structural bearing
19 collar designed to carry load.
20

21 **SEALING AND FIRE STOPPING**

22 **FIRE AND/OR SMOKE RATED PENETRATIONS:**

23 Provide all fire stopping of fire rated penetrations and sealing of smoke rated penetrations in compliance with
24 section 07 84 00 Fire Stopping.
25

26 **NON-RATED PENETRATIONS:**

27 At all interior and exterior walls, through-wall conduit penetrations are required to be sealed. Apply sealant
28 to both sides of the penetration in such a manner that the annular space between the sleeve or cored opening
29 and the conduit is completely blocked.
30

31 **PENETRATIONS SUBJECT TO WATER INTRUSION:**

32 For penetrations (both rated and non-rated) in floors subject to water intrusion or in rooms housing electrical
33 equipment (but not within walls) provide one of the following:

- 34 • Conduit penetration where steel pipe sleeve is used extend steel sleeve 2” above the floor.
- 35 • Conduit penetration where cast in place fire stopping device/sleeve is used, extend device/sleeve 2”
36 above the floor (provided it meets the device’s UL listing).
- 37 • Conduit penetration where there is no steel sleeve or cast in place fire stopping device/sleeve,
38 provide 2”x 2” x 1/8” galvanized steel angles fastened to floor surrounding the penetration or group
39 of penetrations to prevent water from getting to penetration. Provide urethane caulk between angles
40 and floor and fasten angles to floor minimum 8”on center. Seal corners water tight with urethane
41 caulk.
42

43 Floors subject to water intrusion or rooms housing electrical equipment include the following locations:

- 44 • Maintenance/Industrial Shops
- 45 • Vehicle Storage and Parking Ramps
46

47 Provide waterproof caulk sealant top coating on fire stopping system (or other approved means to protect the
48 fire stopping system from water) in areas subject to wash down such as Food Service and Dish Washing
49 Areas.
50

51 **HOUSEKEEPING AND CLEAN UP**

52 The Contractor shall clean up and remove from the premises, on a daily basis, all debris and rubbish resulting
53 from its work and shall repair all damage to new and existing equipment resulting from its work. When job
54 is complete, this Contractor shall remove all tools, excess material and equipment, etc., from the site.
55

56 **AGENCY TRAINING**

57 All training provided for agency shall comply with the format, general content requirements and submission
58 guidelines specified under Section 01 91 01 or 01 91 02.
59

60 Contractor to provide factory authorized representative and/or field personnel knowledgeable with the

1 operations, maintenance and troubleshooting of the system and/or components defined within this section for
2 a minimum period of 1 hour.
3
4

END OF SECTION

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SECTION 26 05 04
CLEANING, INSPECTION, AND TESTING OF ELECTRICAL EQUIPMENT
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

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PART 1 - GENERAL

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SCOPE

34 The work under this section includes the required cleaning, inspection, adjustment, maintenance and testing
35 of electrical equipment, as specified herein. This applies only to new electrical and existing electrical
36 equipment being furnished, modified, worked on or serviced by this contractor for this project. Included are
37 the following topics:

38
39
40
41
42
43
44

PART 1 - GENERAL

Scope

Related Work

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

General Inspection and Cleaning of All Electrical Equipment

Grounding Systems

Lightning Arresters/Surge Suppression

Metering and Instrumentation

Mechanical and Electrical Interlock System

Ground Fault Systems

Panelboards

Cables

Light Fixtures

Occupancy Sensors

Battery Pack Emergency Lighting

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RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

GENERAL INSPECTION AND CLEANING OF ALL ELECTRICAL EQUIPMENT

Inspect for physical damage and abnormal mechanical and electrical conditions.

Any item found to be out of tolerance, or in any other way defective as a result of the required inspection or testing, shall be reported to the DFD. Procedure for repair and/or replacement will be outlined. After appropriate corrective action is completed the item shall be re-tested.

Compare equipment nameplate information with the latest single line diagram and report any discrepancies.

Verify proper auxiliary device operation and indicators.

Check tightness of accessible bolted electrical joints. Use torque wrench/ screw driver method.

Make a close examination of equipment and remove any shipping brackets, insulation, packing, etc. that may not have been removed during original installation.

Make a close examination of equipment and remove any dirt or other forms of debris that may have collected in existing equipment or in new equipment during installation.

Clean All Equipment:

1 Vacuum inside of panelboards, switchboards, switchgear, transformer core and coils, bus ducts,
2 MCC's, and the exterior of all Communications and Electronic Safety and Security
3 hardware and equipment.
4 Loosen attached particles and vacuum them away.
5 Wipe all insulators with a clean, dry, lint free rag.
6 Clean insulator grooves.
7 Re-vacuum inside surfaces as directed by the DFD Construction Representative or Inspector
8

9 Inspect equipment anchorage.

10 Inspect equipment and bus alignment.

11 Check all heater elements for operation and control.

12
13
14
15 Lubricate nonelectrical equipment per manufacturer's recommendations.
16

17 **GROUNDING SYSTEMS**

18 Inspect the ground system for adequate termination at all devices.
19

20 **METERING AND INSTRUMENTATION**

21 Examine all devices for broken parts, damage and wire connection tightness.
22

23 Verify the electronic meter is connected properly and displaying proper voltage and power quantities.
24

25 Inspect nameplate information for compatibility with one-line drawings.
26

27 Verify the instrument transformer connections with the system requirements.
28

29 Verify tightness of all bolted connections and assure adequate clearances exist from primary circuits to
30 secondary circuit wiring and to grounds.
31

32 Verify that all required grounding and shorting connections exist and that those connections make good
33 contact; i.e. sufficient surface area, good cleanliness, and proper pressure.
34

35 Verify proper primary and secondary fuses and required sizes.
36
37

38 **MECHANICAL AND ELECTRICAL INTERLOCK SYSTEM**

39 Physically test each system to insure proper function, operation and sequencing.
40

41 Closure attempt shall be made on locked open devices.
42

43 Opening attempt shall be made on locked closed devices.
44

45 Key exchange shall be made with devices operated in off normal positions.
46
47

48 **GROUND FAULT SYSTEMS**

49 Inspect for physical damage.
50

51 Inspect the neutral main bonding connection to assure:

52 Zero sequence system is grounded upstream of sensor.

53 Ground strap systems are grounded downstream from the sensing device.

54 Ground connection is made ahead of the neutral disconnect link.
55
56

57 **PANELBOARDS**

58 Torque all the connections per the manufacturers spec. Verify phase wires, color coding, separate neutral
59 and mechanical bonding. Verify circuit breaker operation. Verify the directory.
60

61 Vacuum clean the panelboard enclosure.
62
63
64

- 1 **CABLES**
2 600 Volt cable:
3 Visually inspect cables, lugs, connectors and all other components for physical damage and proper
4 connections.
5 Check all cable connectors for tightness (with a torque wrench) and clearances. Torque test
6 conductor terminations to manufacturer's recommendations.
7 Perform a 1000 Vdc megger test on all secondary cables from the substation transformers to the
8 secondary switchboards and on all switchboard feeders.
9
- 10
- 11 **LIGHT FIXTURES**
12 Check the bonding and proper lamping. Verify that recessed fixtures are installed with hold down clips.
13 Confirm operation of the fixture with the proper switch or sensor.
14
- 15 **OCCUPANCY SENSORS**
16 Confirm operation of the sensor per the manufacturer's specification.
17
- 18 **BATTERY PACK EMERGENCY LIGHTING**
19 Verify the operation per the manufacturers spec and run all of the diagnostic steps. Confirm proper grounding
20 and location.
21
- 22 **COMMUNICATIONS AND ELECTRONIC SAFETY AND SECURITY**
23 At equipment rooms:
24 Check all cable and connectors for proper installation and support.
25 Visually inspect cables, lugs, connectors and all other components for physical damage and proper
26 connections.
27 Confirm cable bends to comply with manufacturer's minimum allowable bending radii.
28 Inspect for proper shield grounding, cable support and termination.
29 Confirm all dust caps and blank panels are in place.
30
- 31 Wipe down all equipment racks and cabinets, enclosures, cable supports, cable organizers, termination
32 hardware and related items.
33
- 34 Coordinate cleaning schedule to provide a secure, dust and contaminant-free environment as required to
35 accommodate all trade's equipment that will be positioned in the room. This condition likely will precede
36 general occupancy.
37
- 38 Refer to Division 27 and 28 specification sections that may include additional requirements.
39
- 40

END OF SECTION

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1
2 **SECTION 26 05 19**
3 **LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**
4 **BASED ON DFD MASTER ELECTRICAL SPEC DATED 12/22/21**

5 **PART 1 - GENERAL**

6
7 **SCOPE**

8 The work under this section includes furnishing and installing required wiring and cabling systems including
9 pulling, terminating and splicing. Included are the following topics:

10
11 **PART 1 - GENERAL**

12 Scope
13 Related Work
14 References
15 Submittals
16 Project Conditions

17 **PART 2 - PRODUCTS**

18 General
19 Building Wire
20 Service Entrance Conductors
21
22 Aboveground Wire for Exterior Work
23
24 Emergency Circuits (2-hour rated)
25 Wiring Connectors

26 **PART 3 - EXECUTION**

27 General Wiring Methods
28 Wiring Installation in Raceways
29 Wiring Connections and Terminations
30 Field Quality Control
31 Wire Color
32 Branch Circuits
33 Emergency Circuits
34 Construction Verification Items

35
36 **RELATED WORK**

37 Applicable provisions of Division 1 govern work under this Section.

38
39 Section 26 05 33 – Raceway and Boxes for Electrical Systems.

40 Section 26 05 53 – Identification for Electrical Systems.

41 Section 26 08 00 - Commissioning of Electrical.

42 Section 01 91 01 or 01 91 02 – Commissioning Process

43
44 **REFERENCES**

45 SPS 316- Electrical

46
47 **SUBMITTALS**

48 Submit product data: Provide for each cable assembly type.

49
50 Submit factory test reports: Indicate procedures and values obtained.

51
52 Submit shop drawings for modular wiring system including layout of distribution devices, branch circuit
53 conduit and cables, circuiting arrangement, and outlet devices.

54
55 Submit manufacturer's installation instructions. Indicate application conditions and limitations of use
56 stipulated by product testing agency specified under Regulatory Requirements.

57
58 **PROJECT CONDITIONS**

59 Verify that field measurements are as shown on Drawings.

60
61 Conductor sizes are based on copper.

62
63 Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as
64 required for project conditions.

1
2 Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and
3 lengths required.

4 5 **PART 2 - PRODUCTS**

6 7 **GENERAL**

8 All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of
9 manufacturer's stock.

10 All conductors shall be copper. Aluminum conductors size #1/0 and larger may be substituted for copper and
11 used for phase and neutral conductors for transformer feeders, switchboard feeders, and panelboard feeders.
12 All ground conductors shall be copper.

13
14 Aluminum conductors shall not be used for serving individual motors, chillers, VFD's and motor controllers.

15
16 The following requirements shall be met when aluminum conductors are used:

17
18 Aluminum alloy conductors shall be compact stranded conductors of a recognized Aluminum
19 Association 8000 Series aluminum alloy conductor material (AA-8000 series alloy).

20
21 It is the responsibility of the contractor to increase the size of the conduit, wire gutter, or enclosure,
22 if necessary, to accommodate the aluminum conductors and meet allowable code requirements.

23
24 It is the responsibility of the contractor to increase the size of the aluminum conductor and associated
25 termination lugs to match the ampacity of the copper conductor circuit shown on the Drawings.

26
27 The contractor shall submit a feeder schedule to the Engineer for all conductor substitutions
28 indicating the aluminum conductor wire size and the conduit size. The contractor shall not begin
29 the installation until written approval is granted by the Engineer.

30
31 All aluminum conductors shall terminate on a mechanical screw-type connector or mechanical
32 compression-type connector. Connector shall be dual rated (AL7CU or AL9CU) and Listed by UL
33 for use with aluminum and copper conductors, and sized to accept aluminum conductors of the
34 required ampacity. When using compression-type connectors, the lugs shall be marked with wire
35 size, die index, number and location of crimps and shall be suitably color-coded. Using a suitable
36 stripping tool, remove insulation from the required length of the conductor. Wire brush the
37 conductor and apply a Listed joint compound. Tighten or crimp the connection per the connector
38 manufacturer's recommendation. Wipe off any excess joint compound.

39
40 When terminating aluminum conductors to aluminum bus, prepare a mechanical screw-type or
41 compression-type connection. Bolts shall be anodized alloy and conform to current ANSI and
42 ASTM chemical and mechanical property limits. Nuts shall be aluminum alloy and conform to
43 current ANSI standards. Washers shall be flat aluminum alloy, Type A plain, standard wide series
44 conforming to current ANSI standards. Lubricate and tighten the hardware per manufacturer's
45 recommendations.

46
47 When terminating aluminum conductors to copper bus, prepare a mechanical screw-type or
48 compression-type connection. Bolts shall be plated or galvanized medium carbon steel; heat treated,
49 quenched and tempered equal to current ASTM standard or SAE grade 5. Nuts shall conform to
50 current ANSI standards. Washers shall be steel, Type A plain, standard wide series conforming to
51 current ANSI standards. Belleville conical spring washers shall be of hardened steel, cadmium
52 plated or silicone bronze. Lubricate and tighten the hardware per manufacturer's recommendations.

53
54 The final tightening torque shall be recorded for all aluminum conductor mechanical screw-type
55 connections and provided in report form, in the completed O&M manuals.

56
57 The contractor shall perform an infrared survey of all aluminum conductor connections after the
58 installation is complete and in normal service. Infrared surveys shall be performed during periods
59 of maximum possible loading with at least 30% of rated load of the equipment being inspected. All
60 connections with elevated temperatures shall be corrected by the contractor. The infrared survey
61 results shall be provided in report form, in the completed O&M manuals.

62
63
64 **No copper-to-aluminum transitions permitted when splicing onto existing copper feeders.**

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Insulation shall have a 600 volt rating.

All conductors shall be stranded.

Stranded conductors may only be terminated with UL OR ETL Listed type terminations or methods: e.g. stranded conductors may not be wrapped around a terminal screw but must be terminated with a crimp type device or must be terminated in an approved back wired method.

BUILDING WIRE

Description: Single conductor insulated wire 90 degree C.

Insulation: Type THHN/THWN-2, XHHW-2 insulation.

SERVICE ENTRANCE CONDUCTORS

Description: Single conductor or multi-conductor insulated wire. 90 degree C sized at the 75 degree C table.

Insulation: Type USE-2, XHHW-2 insulation for service entrance conductors routed from exterior source to exterior termination location.

Type XHHW-2 insulation for services entrance conductors routed from exterior source to interior termination location.

ABOVEGROUND WIRE FOR EXTERIOR WORK

Description: Single conductor insulated wire, 90 degree C.

Insulation: Type XHHW-2 insulation.

WIRING CONNECTORS

Split Bolt Connectors: Not acceptable.

Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment terminals. Not approved for splicing.

Twist Type Wire Connectors: Solderless twist type spring connector (wire-nut) with insulating cover for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller. The manufacturer's wire fill capacity must be followed. Use Silicone filled twist type spring connectors in all wet location areas.

Mechanical Spring Actuation Connectors: Toolless type spring actuation connector (push-in) with spacers for copper wire splices and taps. Use for conductor sizes 12 AWG and smaller. The manufacturer's wire fill capacity must be followed. Use in interior, dry locations only.

All wire connectors used in underground or exterior pull boxes or hand holes shall be gel filled twist connectors or a connector designed for damp and wet locations. Gel filled twist type connectors can be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer's wire fill capacity must be followed.

Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.

Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic copper tubing; internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps. Connector must be installed with a crimper tool listed for use with the manufacturer and type of compression connector.

Insulation Piercing Connectors: Molded insulated body, copper teeth, wrench tightened, UL 486B Listed. May be used only for connection of a tap conductor in run and tap type applications when main conductor is 8 AWG and larger.

PART 3 - EXECUTION

GENERAL WIRING METHODS

All wire and cable shall be installed in conduit.

Do not use wire smaller than 12 AWG for power and lighting circuits.

1
2 All phase, neutral and ground conductors shall be sized to prevent excessive voltage drop at rated circuit
3 ampacity. As a minimum use 10 AWG conductors for 20 ampere, 120 volt branch circuit home runs longer
4 than 100 feet (30 m), and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet (61 m).

5
6 Ground conductor size shall be increased per NEC 250.122(B) when phase and phase/neutral conductors are
7 increased in size.

8
9 Make conductor lengths for parallel conductors equal.

10
11 Splice only in junction or outlet boxes.

12
13 No conductor less than 10 AWG shall be installed in exterior underground conduit.

14
15 Identify ALL low voltage wire, 600V and lower, per section 26 05 53.

16
17 Neatly train and lace wiring inside boxes, equipment, and panelboards.

18
19 **WIRING INSTALLATION IN RACEWAYS**

20 Pull all conductors into a raceway at the same time. Use Listed water or silicone based wire pulling lubricant
21 for pulling 4 AWG and larger wires and for other conditions when necessary. Wax based lubricants are not
22 allowed. Pulling lubricant is not required for low friction type products where the cable manufacturer
23 recommends that cables be pulled without lube.

24
25 Install wire in raceway after interior of building has been physically protected from the weather and all
26 mechanical work likely to injure conductors has been completed.

27
28 Completely and thoroughly swab raceway system before installing conductors.

29
30 Place all conductors of a given circuit (this includes phase wires, neutral (if any), and ground conductor) in
31 the same raceway. If parallel phase and/or neutral wires are used, then place an equal number of phase and
32 neutral conductors in same raceway or cable.

33
34 Manufacturers maximum pulling tensions shall be not be exceeded and individual pulls shall not exceed 270
35 degrees.

36
37 VFD Installations: Install VFD input wiring and output wiring in separate conduit systems. Do not mix VFD
38 input power and output power, or control wiring in a common raceway.

39
40 In high ambient spaces, mechanical rooms, utility rooms and exterior exposed conduit, 90 degree C, XHHW-
41 2 conductors shall be utilized.

42
43 **WIRING CONNECTIONS AND TERMINATIONS**

44 Splice only in accessible junction boxes.

45
46 Wire splices and taps shall be made firm, and adequate to carry the full current rating of the respective wire
47 without soldering and without perceptible temperature rise.

48
49 All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the
50 conductor.

51
52 Use solderless twist type spring connectors (wire nuts) with insulating covers for copper wire splices and
53 taps, 10 AWG and smaller or toolless type actuation connectors (push-in) with spacers for copper wire splices
54 and taps, 12 AWG and smaller. Use mechanical or compression connectors for wire splices and taps, 8 AWG
55 and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation
56 value of the wiring.

57
58 Thoroughly clean wires before installing lugs and connectors.

59
60 At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.

61
62 **FIELD QUALITY CONTROL**

63 Field inspection and testing will be performed under provisions of Section 26 05 04.
64

1 Additional testing as follows shall be performed if aluminum conductors are used:
2
3 Feeders terminated with aluminum conductors shall be tested with a thermal imager and recorded.
4
5 Conductors shall be closely checked for loose or poor connections, and for signs of overheating or
6 corrosion.
7
8 Test procedures shall meet NETA guidelines.
9
10 Test results and report shall be provided to the engineer and included in O&M manual under AL
11 conductors/ tests.
12
13 Contractor shall correct all deficiencies reported in the test report.
14

15 **WIRE COLOR**

16 **General:**

17 Solid colored insulation is required for all THHN/THWN-2 wire. For other wire types use colored
18 wire or identify wire with colored tape at all terminals, splices and boxes. Wire shall be colored as
19 indicated below.
20

21 In existing facilities, use existing color scheme.
22

23 In new facilities, use black and red for single phase circuits at 120/240 volts, use Phase A black,
24 Phase B red and Phase C blue for circuits at 120/208 volts single or three phase, and use Phase A
25 brown, Phase B orange and Phase C yellow for circuits at 277/480 volts single or three phase. Note:
26 This includes fixture whips except for Listed whips mounted by the fixture manufacturer on the
27 fixture and Listed as a System.
28

29 Switch legs shall be the same color as their associated circuit, except for the second switch leg used
30 for dual-level switching. The second switch leg shall be the next phase color, e.g. if the first switch
31 leg is brown (277/480V phase A), the second switch leg shall be orange (277/480V phase B).
32

33 Traveler conductors run between 3 and 4 way switches shall be colored pink or purple.
34

35 Neutral Conductors: White for 120/208V and 120/240V systems, Gray for 277/480V systems. Where there
36 are two or more neutrals in one conduit, each shall be individually identified with a different stripe.
37

38 Branch Circuit Conductors: Three or four wire home runs shall have each phase uniquely color coded.
39

40 Feeder Circuit Conductors: Each phase shall be uniquely color coded.
41

42 Ground Conductors: Green colored insulation for THHN/THWN-2 wire. For other wire types use green
43 colored wire or identify wire with green tape at both ends and at all access points, such as panelboards, motor
44 starters, disconnects and junction boxes. When isolated grounds are required, contractor shall provide green
45 with yellow tracer.
46

47 **BRANCH CIRCUITS**

48 The use of single-phase, multi-wire branch circuits with a common neutral is not permitted. All single-phase
49 branch circuits shall be furnished and installed with an individual accompanying neutral, sized the same as
50 the phase conductors.
51

52 **EMERGENCY CIRCUITS**

53 All Emergency, Legally Required Standby and Optional Standby system wiring shall be installed in separate
54 raceways after their associated transfer switches. The wiring shall be separate from each other and from all
55 normal system wiring.
56

57 All emergency wiring serving fire pumps, requiring minimum 2 hour fire rating shall comply with NEC
58 695.6(B).
59

60 All emergency wiring serving NEC 700 loads, requiring minimum 2 hour fire rating shall comply with NEC
61 700.10(D)(1).
62

63 All generator control conductors installed between transfer equipment and the emergency generator serving
64 Emergency, Legally Required Standby and Optional Standby systems shall be kept entirely independent of

1 all other wiring. This shall require a dedicated conduit system between each transfer switch and the
2 emergency generator. If a Fire Pump is served off the emergency generator, a separate conduit shall be
3 provided between fire pump controller and generator.
4

5 **CONSTRUCTION VERIFICATION**

6 Contractor is responsible for utilizing the construction verification checklists supplied under specification
7 Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01
8 or 01 91 02.
9

10 END OF SECTION

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SECTION 26 05 23
CONTROL-VOLTAGE ELECTRICAL POWER CABLES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/21

PART 1 - GENERAL

SCOPE

The work under this section includes furnishing and installing cabling for remote-control, signaling and power-limited circuits. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- References
- Submittals
- Project Conditions

PART 2 - PRODUCTS

General

Wiring Connectors

PART 3 - EXECUTION

- General Wiring Methods
- Wiring Installation In Raceways
- Free-Air Cable Installation
- Wiring Connections and Terminations
- Field Quality Control

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 26 05 33 – Raceway and Boxes for Electrical Systems.

Section 26 05 53 – Identification for Electrical Systems.

Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES

NFPA 70 - National Electrical Code.

SUBMITTALS

Submit product data: Provide for each cable assembly type.

Submit manufacturer's installation instructions. Indicate application conditions and limitations of use stipulated by product testing agency.

PROJECT CONDITIONS

Verify that field measurements are as shown on Drawings.

Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.

Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

GENERAL

All wire shall be new, delivered to the site in unbroken cartons and shall be less than one year old out of manufacturer's stock.

All conductors shall be copper.

Insulation shall have a 600 volt rating.

1 All conductors shall be suitable for the application intended. Conductors #12 and smaller may be solid or
2 stranded with the following requirements or exceptions:

3
4 All conductors terminated with crimp type devices shall be stranded.

5
6 Stranded conductors shall be terminated with an approved ETL Listed type terminations or methods:
7 e.g. stranded conductors shall not be wrapped around a terminal screw but shall be terminated with
8 a crimp type device or in an approved back wired method.
9

10 **WIRING CONNECTORS**

11 Split Bolt Connectors: Not acceptable.

12
13 Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire
14 splices and taps. Use for conductor sizes 10 AWG and smaller.

15
16 All wire connectors used in underground or exterior pull boxes shall be gel filled twist connectors or a
17 connector designed for damp and wet locations.

18 **PART 3 - EXECUTION**

19 **GENERAL WIRING METHODS**

20
21 Control-voltage cables shall be installed in conduit. However, they may be installed free-air (without
22 conduit) above accessible ceilings if the cable meets NEC requirements for the application, unless specified
23 to be in conduit in other sections of the specifications. See requirements for free-air cable installation below.
24

25
26 Control cables for controlling HVAC and lighting equipment connected to emergency power shall be routed
27 in raceway.

28
29 Do not use wire smaller than 14 AWG for control wiring greater than 60 volts, or 18 AWG for voltages less
30 than 60 volts, all sizes subject to NEC 725 requirements.

31
32 Splice only in junction boxes.

33
34 Identify wire per section 26 05 53.

35
36 Neatly train and lace wiring inside boxes, and equipment.

37 **WIRING INSTALLATION IN RACEWAYS**

38
39 Pull all conductors into a raceway at the same time. Use Listed wire pulling lubricant for pulling conditions
40 when necessary.

41
42 Install wire in raceway after interior of building has been physically protected from the weather and all
43 mechanical work likely to injure conductors has been completed.

44 **FREE-AIR CABLE INSTALLATION**

45
46 Cabling shall be neatly run at right angles and be kept clear of other trades work.

47
48 Cabling shall be supported at a maximum of 4-foot intervals utilizing "J-Hook" or "Bridal Ring" supports
49 anchored to ceiling concrete, piping supports or structural steel beams. If cable sag at mid-span exceeds 12-
50 inches, another support shall be provided. Cable supports shall be installed to maintain cable bend to larger
51 than the minimum bend radius.

52
53 Cabling shall not be attached to or supported by existing cabling, plumbing or steam piping, ductwork,
54 suspended ceiling supports or electrical or communications conduit. Do not place cable directly on the ceiling
55 grid or attach cable in any manner to the ceiling grid wires.

56
57 To reduce or eliminate Electro-Magnetic Interference (EMI), the following minimum separation distances
58 for 'Free-Air' cabling installations shall be adhered to:

- 59
- 60 • Twelve (12) inches from power lines of less than 5kV.
 - 61 • Thirty-nine (39) inches from power lines of 5kV or greater.
 - 62 • Five (5) inches from lighting fixtures.
 - 63 • Thirty-nine (39) inches from transformers and motors.
- 64

1 A coil of 4 feet in each cable shall be placed in the ceiling at each 'free-air' wired device. These coils shall
2 be secured (wire tied) at the last cable support before the cable reaches the device and shall be coiled from
3 100% to 200% of the cable recommended minimum bend radius.
4

5 All cable shall be free of tension at both ends. Nylon strain relief connectors shall be provided at each device
6 and junction box where cables enter. In cases where the cable must bear some stress, Kellum type grips may
7 be used to spread the strain over a longer length of cable.
8

9 Cable manufacturers minimum bend radius shall be observed in all instances. Care should be taken in the
10 use of cable ties to secure and anchor the station cabling. Ties should not be over tightened as to compress
11 the cable jacket. No sharp burrs should remain where excess length of the cable tie has been cut.
12

13 All exposed vertical cable extensions to devices located below the finished ceiling shall be in conduit.
14

15 Use suitable cable fittings and connectors.
16

17 When permitted in exposed ceiling areas as designated on the plan drawings, Free-Air wiring runs shall avoid
18 areas of high traffic (i.e. aisle way), shall be run as close as possible to outlining walls and shall be a minimum
19 of ten (10) feet above finished floor. Provide protection for exposed cables where subject to damage.
20

21 **WIRING CONNECTIONS AND TERMINATIONS**

22 Splice only in accessible junction boxes (except splices to low voltage occupancy sensor power packs and
23 terminations to temperature control devices).
24

25 All splices shall be so made that they have an electrical resistance not in excess of two feet (600 mm) of the
26 conductor.
27

28 Use solderless spring type pressure connectors with insulating covers for wire splices and taps, 10 AWG and
29 smaller.
30

31 Thoroughly clean wires before installing lugs and connectors.
32

33 At all splices and terminations, leave tails long enough to cut splice out and completely re-splice.
34

35 **FIELD QUALITY CONTROL**

36 Field inspection and testing will be performed under provisions of Section 26 05 04.
37

38 **END OF SECTION**
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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

The work under this section includes grounding electrodes and conductors, equipment grounding conductors, and bonding for Electrical and Communications systems. Included are the following topics:

PART 1 - GENERAL

Scope
Related Work
References
Performance Requirements
Submittals
Project Record Documents
Regulatory Requirements

PART 2 - PRODUCTS

Rod Electrode
Concrete-Encased Grounding Electrode
Mechanical Connectors
Compression Connectors
Exothermic Connections
Conductors
Bus/Busbar

PART 3 - EXECUTION

Examination
General
Medium Voltage System Grounding
Less Than 600 Volt System Grounding
Communication System Grounding
Field Quality Control
Identification and Labeling
Construction Verification Items
Warranty

All hardware, cables and related termination and support hardware shall be furnished, installed, wired, tested, labeled, and documented by the Contractor, as detailed in this and related sections.

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 26 08 00 - Commissioning of Electrical.
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES

ANSI/IEEE 81 (Latest edition) - Guide to Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System
ANSI/IEEE 142 (Latest edition) - Recommended Practice for Grounding of Industrial and Commercial Power Systems
UL 467 Electrical Grounding and Bonding Equipment
IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding
TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

PERFORMANCE REQUIREMENTS

Grounding System Resistance:

- Equipment Rated 500 KVA and Less: 10 ohms maximum at building service entrance.
- Equipment Rated 500 to 1000 KVA: 5 ohms maximum at building service entrance.
- Equipment Rated more than 1000 KVA: 3 ohms building service entrance.
- Communications Ground Busbars: 5 ohms maximum.

1 Use suitable test instrument to measure resistance to ground of system. Perform testing in accordance with
2 test instrument manufacturer's recommendations. Perform fall-of-potential test in accordance with ANSI/
3 IEEE 81 on main grounding electrode system.
4

5 **Testing of grounding system resistance is to be witnessed by the DFD Electrical Inspector or**
6 **Construction Representative.**
7

8 **Provide test report of grounding system overall resistance and resistance of each electrode in final**
9 **O&M manuals and noted on record documents.**
10

11 **SUBMITTALS**

12 Product Data: Provide data for grounding electrodes and connections.
13

14 Provide samples of ground labels.
15

16 Test Reports: Indicate overall resistance to ground and resistance of each electrode.
17

18 Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic
19 connectors.
20

21 **PROJECT RECORD DOCUMENTS**

22 Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding
23 conductors as installed including recorded ground resistance test results.
24

25 **REGULATORY REQUIREMENTS**

26 Conform to requirements of NFPA 70.
27

28 Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to
29 authority having jurisdiction as suitable for purpose specified and shown.
30

31 **PART 2 - PRODUCTS**

32 **ROD ELECTRODE**

33 Material: Copper-clad steel.
34

35 Diameter: 3/4 inch (19 mm) minimum.
36

37 Length: 10 feet (3.5 m) minimum. Rod shall be driven at least 9' 6" deep.
38
39

40 **CONCRETE-ENCASED GROUNDING ELECTRODE FOR BUILDINGS**

41 Fabricate per NFPA 70, Article 250.52 (A)(3)(2) using 20 feet (6m) of bare copper wire not smaller than bare
42 seven-strand #4 AWG. Metallic components shall be encased by at least 2 in. of concrete and shall be located
43 horizontally with in that portion of a concrete foundation or footing that is in direct contact with earth or
44 within vertical foundations or structural components or members that are in direct contact with the earth.
45

46 **MECHANICAL CONNECTORS**

47 The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper
48 alloy material. Bolts, nuts, washers and lock washers shall be made of Silicon Bronze and supplied as a part
49 of the connector body and shall be two hole, two bolt type.
50

51 Split bolt connector types are NOT allowed. Exception: the use of split bolts is acceptable for grounding of
52 wire-basket type cable tray, and for cable shields/straps of medium voltage cable.
53

54 The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size
55 and manufacturer.
56

57 **COMPRESSION CONNECTORS**

58 The compression connectors shall be manufactured from pure wrought copper. The conductivity of this
59 material shall be no less than 99% by IACS standards.
60

61 Each connector shall be factory filled with an oxide-inhibiting compound.
62

63 The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.
64

1
2 The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the
3 required compression tool settings.
4
5 The installation of the connectors shall be made with a compression tool and die system, as recommended
6 by the manufacturer of the connectors, and shall be irreversible.
7
8 Pre-crimping of the ground rod is required for all irreversible compression connections to a ground rod.
9
10 Terminal lug for communication system grounding shall be compression type and conform to the following:
11 Material: Tin Plated Copper (aluminum not permitted).
12 Wire Size: to match conductor
13 Number of Stud Holes: 2
14 Stud Hole Size: 3/8"
15 Bolt Hole Spacing: per TIA-607-C
16 Tongue Angle: Straight
17

18 **EXOTHERMIC CONNECTIONS**
19 As manufactured by Erico Cadweld, Harger Ultraweld or similar.
20

21 **CONDUCTORS**
22 Material: Stranded copper (aluminum not permitted).
23
24 Grounding Electrode Conductor: Bare seven-strand conductors. Size as shown on drawings, specifications
25 or as required by NFPA 70, whichever is larger.
26
27
28 Foundation Electrodes: As shown on drawings.
29
30 Primary Manhole, Main Switchgear room and Vault Bonding: No. 4/0 minimum.
31
32 Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by
33 NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both
34 are used at the same facility.
35
36 Branch Circuit Equipment Ground shall be proportionately increased in size when routed with phase
37 conductors increased in size.
38
39 Conductors for Telecommunications shall be as follows:
40 Telecommunications Bonding Conductor (TMGB to Service Ground): No. 3/0 minimum or as
41 shown on drawings.
42 Telecommunications Bonding Backbone (TBB; TMGB to TGB): No. 3/0 minimum or as shown on
43 drawings.
44 Telecommunications Grounding Equalizer (GE): No. 3/0 minimum or as shown on drawings.
45 Bonding Conductors shall be insulated with a Green Jacket or jacket marked with Green Tape or
46 labeled per NEC Guidelines.
47
48
49

50 **BUS/BUSBAR**
51 Material: Copper (aluminum not permitted).
52
53 Size:
54 All Power systems: 1/4" X 2", length as needed (24" minimum).
55 Telecommunications Main Ground Busbar (TMGB): 1/4" x 4" x 20" long (minimum).
56 Telecommunications Grounding Busbar (TGB): 1/4" x 2" x 12" long (minimum).
57
58 Busbars:
59 Be pre-drilled to accommodate two-hole lugs.
60 3/8" stud hole size; hole spacing per TIA-607-C.
61 Incorporate insulators and stand-off brackets that electrically isolate busbar from mounting surface.
62

1 Provide main ground busbar located adjacent to main electrical service equipment to terminate all ground
2 conductors. Refer to DFD grounding detail 26 05 26-1.

4 **PART 3 - EXECUTION**

6 **EXAMINATION**

7 Verify that final backfill and compaction has been completed before driving rod electrodes.

9 **GENERAL**

10 Install Products in accordance with manufacturer's instructions.

11 Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over
12 mechanical ground connections.

13 Ground connection surfaces shall be cleaned and all connections shall be made so that it is impossible to
14 move them. Attach grounds permanently before permanent building service is energized.

15 All grounding conductor connections to Busbars shall be via two hole lugs.

16 Terminate each grounding conductor on its own terminal lug. Sharing a single lug by multiple conductors
17 is not allowed.

18 All grounding electrode conductors and individual grounding conductors shall be installed in SCH 80 PVC
19 conduit, in exposed locations.

20 Each grounding electrode conductor shall be labeled at each terminated end as to system served and location
21 of second termination.

23 **MEDIUM VOLTAGE SYSTEM GROUNDING**

24 Provide and install a 1/4" x 2" ground bus 18" above finished floor with insulated standoffs 36" on center,
25 completely around the perimeter of the room (vault) containing the medium voltage switchgear and unit
26 substation. Route bus over door. All connections to bus shall be bolted with Belleville washers and tool
27 applied compression spade lugs (2 hole) or exothermic.

28 Provide a minimum of six (6) ground rods equally spaced around the perimeter of the high voltage switchgear
29 room or as indicated by the drawings, whichever is greater. [Connect ground rods to perimeter ground bus
30 with 4/0 copper conductor. Connection from ground rod to conductor shall be irreversible compression or
31 exothermic. Pre-crimping of the ground rod is required for all irreversible compression connections.
32 Connection from ground bus to conductor shall be bolted with Belleville washers and tool applied
33 compression spade lugs (2 hole) or exothermic.

34 Provide separate 4/0 copper conductor from perimeter ground bus to:
35 XO terminal of each transformer.
36 Each high voltage switch ground bus.
37 Secondary service equipment ground bus.
38 Transformer high voltage grounded terminal (if applicable).

39 Provide full size 600V copper THHN/THWN or XHHW-2 grounding conductor in each conduit, raceway or
40 enclosure which contains high voltage conductors. Terminate at ground bus of equipment containing high
41 voltage terminations. Connect to ground rod and grounding conductor in each manhole.

42 Bond each enclosure containing high voltage parts (switches, fuses, transformers, pull boxes, etc.) to room
43 ground bus with 4/0 copper conductor.

44 Bond all conduits containing high voltage conductors or secondary service conductors to penetrated
45 enclosures using grounding bushing and #4 copper conductor. Attach to penetrated enclosures using
46 grounding bushing and #4 copper conductor. Attach to penetrated enclosure using compression lug on stud
47 or bolt and Belleville washers.

48 Provide #10 stranded wire from each high voltage termination shield drain wire to ground bus within
49 enclosure. Connect to nearest grounded conductor if ground bus is not within 24". Route shield drains away
50 from energized parts. Make connections with "Sta-Kon" type terminals or tool applied tap connectors. Use
51 of split bolts is acceptable when braided drain wires are used.

1
2 Bond all conduits carrying individual grounding or grounding electrode conductors with grounding bushing
3 and separate #4 copper grounding conductor to ground bus.
4
5 Provide ground rod in each section of each secondary switchboard. Connect ground rod to ground bus with
6 4/0 copper conductor and irreversible compression connectors or exothermic.
7
8 **LESS THAN 600 VOLT ELECTRICAL SYSTEM GROUNDING**
9
10
11 Supplementary Grounding Electrode: [Use driven ground rod on exterior of building.] [Use effectively
12 grounded metal frame of the building.]
13
14 Provide code sized copper grounding electrode conductor from electrical room ground bus to secondary
15 switchboard ground bus, each separately derived system neutral, secondary service system neutral to street
16 side of water meter, building steel, ground rod, and any concrete encased electrodes. Provide bonding jumper
17 around water meter. Provide physical protection as required.
18
19 Equipment Grounding Conductor: Provide separate, insulated equipment grounding conductor within each
20 raceway. Terminate each end on suitable lug, bus, enclosure or bushing. Provide a ground wire from each
21 device to the respective enclosure.
22
23 Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of
24 electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground
25 connectors, and plumbing systems.
26
27 Install ground grid under access floors. Construct grid of #4 AWG bare copper wire installed on 72 inch
28 centers both ways. Bond each access floor support pedestal to grid.
29
30 Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors.
31 Bond to under floor ground grid. Use #4 AWG bare copper conductor.
32
33 **COMMUNICATION SYSTEM GROUNDING**
34
35
36 Grounding and Bonding System for Communications shall be an isolated grounding system with a single
37 ground point. That ground point is to be the common grounding electrode system at the building electrical
38 service entrance (main ground bar located in electrical room).
39
40 The system shall be compliant with ANSI J-STD-607-B with the exception that the ground cable shall not
41 be bonded to building steel except at the electrical service entrance.
42
43 Provide Grounding Busbar for Telecommunications at each Telecommunications Room, the Main
44 Equipment Room and at the electrical service entrance per project drawings. Coordinate Busbar location(s)
45 and conductor routing per drawings with Division 27 contractor.
46
47 Provide Telecommunications Bonding Conductor from Telecommunications Main Grounding Busbar
48 (TMGB) at the Communications Entrance Facility to building common grounding electrode system. Attach
49 grounding conductor to building steel as allowed only at the main electrical service entrance. Provide physical
50 protection as required.
51
52 Provide Telecommunications Bonding Backbone (TBB) conductor from the TMGB to Telecommunications
53 Grounding Busbar (TGB) at each Telecommunication Room, Telecommunications Equipment Room and
54 Telecommunications Enclosure.
55 TBB shall be continuous and not connected through Telecommunications Grounding Busbars
56 (TGBs).
57 Bond TGBs to TBB via tap off of TBB. Gauge of conductor to be same as TBB.
58 Leave 10 feet slack in conductor from TBB to TGB at TGB location(s).
59 Do not bond TBB or TGB to building steel at TGB location(s).
60
61 Provide Grounding Equalizer(s) (GE) per project drawings. Connect GE conductor directly to TGBs being
62 interconnected.
63
64 **FIELD QUALITY CONTROL**

1 Inspect grounding and bonding system conductors and connections for tightness and proper installation.

2
3 Testing of grounding system resistance is to be witnessed by the DFD Electrical Inspector or Construction
4 Representative. Provide test report of grounding system resistance in final O&M manuals and noted on
5 record drawings.

6
7 Provide resistance test at each electrical and telecommunications Busbar to ground.

8
9 **IDENTIFICATION AND LABELING**

10 Label Grounds at point of termination.

11
12 Label for Bus Bars and Ground Bars shall be engraved laminate or Pre-printed (manufactured) plastic and
13 include the following:

14
15
16 IF THIS CONNECTOR OR CABLE IS
17 LOOSE OR MUST BE REMOVED,
18 PLEASE CALL THE BUILDING
19 MANAGER.
20

21
22
23 Provide additional labeling of each individual terminated ground conductor at bus bar identifying installed
24 source per NEC 250.52 A 1-7.

25
26
27 Label for TBB connection at TMGB and TGB(s) shall be engraved laminate or Pre-printed (manufactured)
28 plastic and include the following:

29
30
31 IF THIS CONNECTOR OR CABLE IS
32 LOOSE OR MUST BE REMOVED,
33 PLEASE CALL THE BUILDING
34 TELECOMMUNICATIONS
35 MANAGER.
36

37 **CONSTRUCTION VERIFICATION**

38 Contractor is responsible for utilizing the construction verification checklists supplied under specification
39 Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01
40 or 01 91 02.

41
42 Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding
43 conductors as installed including recorded ground resistance test results.

44
45 **WARRANTY**

46 See Division 1, General Conditions, and General Requirements.

47
48
END OF SECTION

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SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

The work under this section includes conduit and equipment supports, straps, clamps, steel channel, etc., and fastening hardware for supporting electrical work. Included are the following topics:

PART 1 - GENERAL

Scope
Related Work
Submittals
Quality Assurance

PART 2 - PRODUCTS

Support Channel
Conduit Supports
Nylon Anchors
Threaded Rod
Hardware

PART 3 - EXECUTION

Installation

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

Section 26 05 53 – Identification for Electrical Systems

SUBMITTALS

Product Data: Provide data for support channel.

QUALITY ASSURANCE

Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

SUPPORT CHANNEL

Epoxy Painted

Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS Grade 33, then painted with water born epoxy applied by a cathodic electro-deposition process.

All fittings and hardware shall be zinc plated in accordance with ASTM B633 (SC3 for fittings, SC1 for threaded hardware).

Hot-dip Galvanized Steel

Strut shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 and shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

Fittings shall be manufactured from steel meeting the minimum requirements of ASTM A907 SS, Grade 33, and hot-dip galvanized after fabrication in accordance with ASTM A123.

All hardware shall be stainless steel Type 304 or chromium zinc ASTM F1136 Gr. 3.

All hot-dip galvanized after fabrication products must be returned to point of manufacture after coating for inspection and removal of all sharp burrs.

Stainless Steel

All strut, fittings and hardware shall be made of AISI Type 304 or Type 316 stainless steel as indicated.

CONDUIT SUPPORTS

Conduit clamps, straps, supports, etc., shall be steel or malleable iron.

1 One-hole straps shall be heavy duty type. All straps shall have steel or malleable backing plates when rigid
2 steel conduit is installed on the interior or exterior surface of any exterior building wall.

3
4 Bar joist conduit/box hangers: Spring Steel Clips with Snap-Close Clamps (Conduit Supports): Conduit
5 clamps shall pivot a full 360 degrees and shall snap close around the conduit. Push-in type conduit clamps
6 are not allowed. Spring clips shall require a hammer to install onto supporting surface.

7
8 Stud wall applications: Spring Steel Clips with Push-in or Snap-Close Conduit Clamps (Conduit Supports):
9 Conduit clamps shall pivot a full 360 degrees. Spring clips shall require a fastener to install onto stud.

10
11 Box/conduit hanger with rod/wire clip (a.k.a. antlers): One assembly provides support for electrical box and
12 conduit from drop wire or rod. Conduit clamps shall snap close around the conduit.

13
14 Spring Steel Clip products shall be provided with corrosion resistance and be warranted against failure from
15 corrosion for a period of ten (10) years from date of manufacture.

16 **NYLON ANCHORS**

17 Nylon anchors may only be used in limited applications with the pre-approval of the State of Wisconsin DFD
18 Electrical Inspector. See Part 3 – Execution for examples of applications of where nylon anchors may be
19 allowed.

20
21
22 Nylon wall plugs shall be designed for 2-way expansion, providing rapid fixing with high pull-out values.
23 Nylon wall plugs shall be molded with protruding side fins which restrict rotation and prevent fall out from
24 overhead holes. Examples of these include Mungo types MN or MU, or Fischer type S nylon plugs.

25
26 Nylon one-piece self-drilling anchors designed for use in hollow gypsum wallboard for light duty loads.
27 Anchors shall be engineered nylon or Zamac alloy. Examples of these are the Zip-It ® or Zip-It Jr. ® self-
28 drilling anchors.

29
30 Manufacturer's names and catalog numbers are used for quality and performance only. Anchors manufactured
31 by others shall be equally acceptable provided they meet or exceed in performance and quality as specified.

32 **THREADED ROD**

33 Minimum sized threaded rod for supports shall be 3/8" for trapezes and single conduits 1-1/4" and larger,
34 and 1/4" for single conduits 1" and smaller.

35 **HARDWARE**

36 Corrosion resistant, or as noted for each product above.

37 **PART 3 - EXECUTION**

38 **INSTALLATION**

39 Fasten hanger rods, conduit clamps, and outlet-, junction-, and pull-boxes to building structure using pre-cast
40 insert system, preset inserts, beam clamps, or expansion anchors.

41
42 Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls;
43 expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchors on
44 concrete surfaces; sheet metal screws in sheet metal studs and wood screws in wood construction. If nail-in
45 anchors are used, they must be removable type anchors.

46 Powder-actuated fasteners are not permitted.

47 Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit.

48 Do not fasten to suspended ceiling systems.

49 Do not drill structural steel members unless approved by DFD.

50
51 In wet locations, mechanical rooms, and electrical rooms, install free-standing electrical equipment on 3.5-
52 inch (89 mm) concrete pads.

1 Install surface-mounted cabinets and panelboards with a minimum of four anchors. At all cabinet and
2 panelboard locations on concrete or concrete block walls, and at ALL locations below grade, provide steel
3 channel supports to stand cabinet one inch (25 mm) off wall (7/8" Uni-strut or 3/4" painted fire-retardant
4 plywood is acceptable). In above-grade equipment rooms that have drywall walls, the cabinets and
5 panelboards may be mounted to the drywall if backing is provided in the stud walls behind the equipment.
6

7 Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.
8

9 Furnish and install all supports as required to fasten all electrical components required for the project,
10 including free standing supports required for those items remotely mounted from the building structure,
11 catwalks, walkways etc.
12

13 Fabricate supports from galvanized structural steel or steel channel, rigidly welded or bolted to present a neat
14 appearance. Use hexagon head bolts with spring lock washers under all nuts.
15

16 **Support Channel**

17 Use one of the following types of support channel as appropriate for the installed environment:

- 18 • Indoor: Epoxy Painted Steel, Hot-dipped Galvanized Steel, or as noted on the drawings.
19
- 20 • Exterior and wet locations: Hot-dipped Galvanized Steel or Stainless Steel, as appropriate for the
21 environment or as noted on the drawings. Type 316 stainless steel shall be used for Food Service
22 type environments. Epoxy painted support channel shall not be used for exterior installations.
23
- 24 • Manholes, steam pits, steam tunnels, or corrosive environments: Stainless Steel Type 316.
25
- 26 • Field cuts: File and de-bur cut ends of support channel and paint to prevent rusting. For epoxy-
27 painted support channel, paint cut ends to match the original color. For hot-dipped galvanized
28 support channel, spray cut ends with cold galvanized paint.
29

30 **Support Wires**

31 Support wires that are installed in addition to the ceiling grid support wires to provide secure support for
32 raceways, cables assemblies, boxes, cabinets, and fittings shall be secured at both ends (e.g., the ceiling
33 structure at the top and the ceiling grid at the bottom) per NEC 300.11(A).
34

35 Compressed-air power-actuated fasteners may ONLY be used for the installation of separate ceiling wires
36 required for support of conduits and aircraft cable hung light fixtures.
37

38 Support wires shall be identified per specification section 26 05 53.
39

40 **Spring Steel Clip Conduit Supports for 30 amp or less branch circuits**

41 Spring steel clips with snap-close clamps may be used to support conduit/ box from bar joist (steel truss)
42 systems.
43

44 Stud wall applications: Spring steel clips with push-in or snap-close conduit clamps may be used to support
45 conduit in interior metal stud wall applications. Use screw fasteners to install conduit clamp onto stud.
46

47 Conduit/box hanger with rod/wire clip (a.k.a. antlers) and multi conduit/box support systems: Above
48 suspended ceiling only.
49

50 **Nylon anchor applications**

51 Nylon anchors may only be used in limited light duty applications with the pre-approval of the State of
52 Wisconsin DFD Electrical Inspector.
53

54 Nylon anchors shall be designed for the construction material in which they are intended to be installed and
55 shall be designed for the weight in which the anchors are intended to support.
56

57 Nylon wall plug applications may include attaching 4" square boxes or conduit straps to plaster-covered clay
58 tile, drywall, or hollow concrete block. Screws used with nylon wall plugs shall be #10 minimum and shall
59 be longer than the anchor.
60

1 Nylon one-piece self-drilling anchor applications may include attaching 4" square boxes or conduit straps to
2 hollow gypsum wallboard for light duty loads. Use No. 8 screws with one-piece self-drilling anchors designed
3 for 3/8" to 1" thick wallboard. Use No. 6 screws with anchors designed for 3/8" to 5/8" wallboard.

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END OF SECTION

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SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

This section describes the products and execution requirements relating to furnishing and installing raceways and boxes and related systems as part of a raceway system for electrical, communications, and other low-voltage systems for the project. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- References
- Submittals

PART 2 - PRODUCTS

- General
 - Rigid Metal Conduit (RMC) and Fittings
 - PVC Coated Rigid Metal Conduit
 - Intermediate Metal Conduit (IMC) and Fittings
 - Electrical Metallic Tubing (EMT) and Fittings
 - Flexible Metal Conduit (FMC) and Fittings
 - Liquidtight Flexible Metal Conduit (LFMC) and Fittings
 - Electrical Nonmetallic Tubing (ENT) and Fittings
 - Rigid Polyvinyl Chloride Conduit (PVC) and Fittings
 - Fiberglass Resin Conduit (RTRC) and Fittings
 - High Density Polyethylene Conduit (HDPE) and Fittings
- Conduit Supports
- Surface Metal Raceway
- Surface Nonmetal Raceway
- Multi-Outlet Assembly
- Auxiliary Gutters (Wireways)
- Conduit Water Sealant
- Pull and Junction Boxes
- In Grade Handholes and Boxes
- Outlet Boxes
- Outlet Box Extenders

PART 3 - EXECUTION

- Conduit Sizing, Arrangement, and Support
- Conduit Installation
- Conduit Installation Schedule
- PVC Coated Rigid Metal Conduit Installation
- High Density Polyethylene Conduit (HDPE) Installation
- Surface Metal Raceway and Multi-Outlet Assembly Installation
- Nonmetallic Surface Raceway Installation
- Auxiliary Gutters (Wireways) Installation
- Coordination of Box Locations
- Pull and Junction Box Installation
- In Grade Handholes and Boxes
- Outlet Box Installation Construction Verification Items

RELATED WORK

Applicable provisions of Division 1 govern work under this section.

- Section 01 91 01 or 01 91 02 – Commissioning Process
- Section 26 08 00 - Commissioning of Electrical.
- Section 26 05 26 – Grounding and Bonding for Electrical Systems
- Section 26 05 29 – Hangers and Supports for Electrical Systems.
- Section 26 05 34 -- Underground HDPE Pathways for Electrical Systems
- Section 26 27 02 – Equipment Wiring Systems.
- Section 26 27 26 – Wiring Devices.
- Section 27 10 00 - Structured Cabling

1 **REFERENCES**

2 Wisconsin Administrative Code SPS 316 - Electrical
3 ANSI/TIA-569-C-Telecommunications Pathways and Spaces
4 ANSI/SCTE 77-2017 – Specifications for Underground Enclosure Integrity
5

6 **SUBMITTALS**

7 Surface Raceway System - submit product data and catalog sheets for all components.
8

9 Boxes - provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.
10

11 Conduits in Concrete Slabs Above Grade - provide proposed conduit routing and sizing to Structural Engineer
12 prior to approval of installation to verify structural integrity and fire rating of concrete slab.
13

14 Mockups -- Provide on request, mockups for Floor Box and Poke-through Assemblies to demonstrate
15 configuration, capacity and aesthetics and to set quality standards for fabrication and installation. Coordinate
16 with Division 26 and Division 27 requirements as applicable to include all power and communications
17 devices.
18
19

20 **PART 2 - PRODUCTS**

21
22
23 **GENERAL**

24 All steel fittings and conduit bodies shall be galvanized.
25

26 All conduit transitional fittings shall be listed for installed application.
27

28 Condulet fittings shall be threaded rigid entering condulets.
29

30 No cast metal or split-gland type fittings permitted.
31

32 All condulet covers must be fastened to the condulet body with screws and be of the same manufacture.
33

34 Mogul-type condulets 2 inch (50 mm) and larger, shall be permitted.
35

36 C-condulets shall not be used in lieu of pull boxes.
37

38 All boxes shall be of sufficient size to provide free space for all conductors enclosed in the box and shall
39 comply with NEC requirements.
40

41 **RIGID METAL CONDUIT (RMC) AND FITTINGS**

42 Conduit: Heavy wall threaded, galvanized steel.
43

44 Fittings and Conduit Bodies: Use all steel threaded fittings and conduit bodies.
45

46 Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely
47 on external bonding jumpers to maintain grounding continuity between raceway components.
48

49 **PVC COATED RIGID METAL CONDUIT**

50 PVC Externally Coated Conduit: Rigid heavy wall, schedule 40, steel conduit with external 40 mil (0.1 mm)
51 PVC coating. Conduit must be hot dipped galvanized inside and out including threads. The PVC coating
52 bond to the galvanized steel conduit shall be stronger than the tensile strength of the coating itself.
53

54 Fittings and Conduit Bodies: Threaded type, material to match conduit. PVC coated fittings and couplings
55 shall have specially formed sleeves to tightly seal to conduit PVC coating. The sleeves shall extend beyond
56 the fitting or coupling a distance equal to the pipe outside steel diameter or two inches (50 mm) whichever is
57 greater.
58

59 **INTERMEDIATE METAL CONDUIT (IMC) AND FITTINGS**

60 Conduit: Galvanized Steel, threaded.
61

62 Fittings and Conduit Bodies: Use all Steel threaded fittings and conduit bodies.
63

1 Expansion Fittings/Expansion Joints: Expansion Fittings shall be Internal Grounding type and shall not rely
2 on external bonding jumpers to maintain grounding continuity between raceway components.
3
4 Aluminum conduits shall not be in direct contact with concrete.
5
6 **ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS**
7 Conduit: Steel, Unthreaded thin wall galvanized tubing.
8
9 Fittings: All steel, compression or set screw type. No push-on or indenter types permitted.
10
11 Transitional fitting: ½-1": All steel and malleable iron; 1 ¼" and above: All steel, Malleable iron and Die
12 cast where not subjected to physical damage and with project specific DFDM electrical inspector approval.
13
14 Conduit Bodies: All steel conduit bodies.
15
16 **FLEXIBLE METAL CONDUIT (FMC) AND FITTINGS**
17 Conduit: steel, galvanized, spiral strip.
18
19 Fittings and Conduit Bodies: All steel, galvanized or malleable iron (except as allowed in specification 26 51
20 13).
21
22 **LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC) AND FITTINGS**
23 Conduit: flexible, steel, galvanized, spiral strip with an outer Liquidtight, nonmetallic, sunlight-resistant
24 jacket.
25
26 Fittings and Conduit Bodies: ANSI/NEMA FB 1, compression type. There shall be a metallic cover/insert on
27 the end of the conduit inside the connector housing to seal the cut conduit end.
28
29 **ELECTRICAL NONMETALLIC TUBING (ENT) AND FITTINGS**
30 Conduit: ENT (smurf tube), UL listed and NEC recognized.
31
32 Fittings: One piece quick connect fittings for 1/2 inch to 1 inch size and schedule 40 cemented fittings for
33 larger size. When installed in concrete, fittings shall be suitable for damp locations and shall be concrete-
34 tight, stub-ups and stub-downs kits shall meet manufacturer's recommendations.
35
36 **RIGID POLYVINYL CHLORIDE CONDUIT (PVC) AND FITTINGS**
37 Conduit: Rigid non-metallic conduit, Schedule 40 PVC minimum, Listed, sunlight resistant, rated for 90° C
38 conductors. Schedule 80 for locations exposed to physical damage or as required.
39
40 Fittings and Conduit Bodies: NEMA TC 2, Listed.
41
42 **FIBERGLASS RESIN CONDUIT (RTRC) AND FITTINGS:**
43 Conduit: Reinforced Thermosetting Resin Conduit RTRC, Type AG (Above Ground) and XW (Exposed),
44 and UL 2515 AG (Above Ground) or UL 2420 BG (Below Ground) listed.
45
46 The conduit shall be free from defects including delamination's, foreign inclusions, etc. It shall be nominally
47 uniform in color, density, and physical properties. It shall be straight and the ends shall be cut square to the
48 inside diameter. The resin system shall be epoxy anhydride-cured with no fillers. Glass shall be (E-type or
49 E-CR).
50
51 Joining Methods: Interference Joint – the conduit shall be supplied with an integrally wound tapered bell and
52 machine tapered spigot which shall provide a concrete tight and watertight fit with a minimum pullout
53 strength of 500 lbs. when tested in accordance with ASTM D 2105.
54
55 Fittings: A complete line of fittings, adaptors, and elbows shall be available and shall be manufactured from
56 the same materials and process as the conduit.
57
58 Sizes: Conduit and fittings shall be manufactured to IPS and ID trade sizes.
59
60 Flammability: Conduit and fittings shall conform with UL 2515.
61
62 Hangers and Supports: When supporting or hanging conduit on a wall or structure, the manufacturer
63 supplying the conduit shall also supply the hangers and supports. Third party materials shall not be allowed.
64

1 Thermal:

2 Conduit and fittings shall conform with the following:

3 Heat Deflection Temperature:	312° F per ASTM D 648
4 Continuous Operating Temperature	-40° to 250° F (-40° C to 110° C)
5 Maximum Operating Temperature	-60° to 260° F (-60° to 130° F)
6 Coefficient of Thermal Expansion	1.25 x 10 ⁻⁵ in/in/F per ASTM D 696

7
8 Impact Resistance: Conduit and fittings shall conform with minimum impact resistances as required by UL
9 2515.

10 Compression Resistance: Conduit shall not decrease by more than 25% during testing set forth in UL 2515.

11 Pipe Stiffness: Conduit stiffness shall meet or exceed the standards set forth in ASTM D2412.

12
13 **HIGH DENSITY POLYETHYLENE CONDUIT (HDPE) AND FITTINGS**

14 See specification Section 26 05 34 -- Underground HDPE Pathways for Electrical Systems

15
16 **CONDUIT SUPPORTS**

17 See specification Section 26 05 29.

18
19 **CONDUIT WATER SEALANT**

20 Description: Conduit sealant used to prevent water from entering buildings via conduits.

21 Sealant shall seal conduits against water and gas intrusion, such as Polywater® FST™-250 Foam Duct
22 Sealant, Raychem RDSS Rayflute Duct Sealing System, or approved alternate. Sealant shall be re-enterable,
23 shall be compatible with the conduit and conductor types being used, and shall comply with NEC 225.27,
24 230.8, and 300.5(G).

25 Manufacturer names and catalog numbers are used to develop quality and performance requirements only.
26 Products manufactured by others may be acceptable provided they meet or exceed the specifications.

27
28 **PULL AND JUNCTION BOXES**

29 Interior Sheet Metal Boxes: code gauge galvanized steel, screw covers, flanged and spot-welded joints and
30 corners.

31 Interior Sheet Metal Boxes larger than 12 inches (300 mm) in any dimension shall have a hinged cover or a
32 chain installed between box and cover. Boxes 9 square-feet or larger shall have hinged covers and a single
33 cover shall not exceed 10 square-feet.

34 Interior Sheet Metal Boxes connected to an exterior underground raceway, shall have a drain fitting located
35 in the bottom.

36 Exterior Boxes and Wet Location Installations: Type 4 and Type 6, flat-flanged, surface-mounted junction
37 box, UL listed as rain-tight. Aluminum box and cover with ground flange, neoprene gasket, and stainless
38 steel cover screws.

39 Boxes installed in Parking Ramps shall be Type 4X, flat-flanged, surface-mounted junction box, ETL listed
40 as rain-tight. Stainless Steel box and cover with ground flange, neoprene gasket, and stainless steel cover
41 screws.

42 Box extensions and adjacent boxes within 48 inches of each other are not allowed for the purpose of creating
43 more wire capacity.

44 Junction boxes 6 inch-by-6 inch or larger size shall be without stamped knock-outs.

45 Wireways shall not be used in lieu of junction boxes.

46
47 **IN GRADE HANDHOLES AND BOXES**

48 Handholes and Boxes: Polymer- Concrete.

49 Handhole and Box Covers: Polymer- Concrete

50 Handhole and box bottoms: Integral Closed

1
2 Handholes and boxes for use in underground systems shall be designed and identified as defined in NFPA
3 70, for intended location and application.
4
5 Handhole and cover Assembly Load Rating: ANSI/SCTE Tier22 or better.
6
7 Covers: Weatherproof, secured by tamper-resistant locking devices with non-skid finish.
8 Cover Label: SECURITY SYSTEM FIBER OPTICS
9
10 Units shall be designed – typically with a flared wall and footed base – to prevent frost heaving. Refer to
11 drawings for handhole dimensions on sheet C100.
12

13 **OUTLET BOXES**

14 Sheet Metal Outlet Boxes: galvanized steel, with stamped knockouts.

15
16 Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 3/8 inch
17 male fixture studs where required.

18
19 Concrete Ceiling Boxes: Concrete type.

20
21 Cast Boxes: Cast ferroalloy or aluminum, deep type, gasketed cover, threaded hubs.

22 **OUTLET BOX**

23
24 Outlet Box Extenders: Non-Metallic, adjustable depth.

25
26 Outlet Box Extenders may only be used in limited applications with the pre-approval of the State of
27 Wisconsin DFD Electrical Inspector. See Part 3 – Execution for examples of applications of where Outlet
28 Box Extenders may be allowed.
29

30 **PART 3 - EXECUTION**

31 **CONDUIT SIZING, ARRANGEMENT, AND SUPPORT**

32
33 EMT is permitted to be used in sizes 4 inch (100 mm) and smaller for power and low-voltage systems. See
34 CONDUIT INSTALLATION SCHEDULE below for other limitations for EMT and other types of conduit.
35

36
37 Size power conductor raceways for conductor type installed. Conduit size shall be 1/2 inch (16 mm) minimum
38 except **all homerun conduits shall be 3/4 inch (21 mm)**, or as specified elsewhere. **Caution: Per the NEC,**
39 **the allowable conductor ampacity is reduced when more than three current-carrying conductors are**
40 **installed in a raceway. Contractor must take the NEC ampacity adjustment factors into account when**
41 **sizing the raceway and wiring system.**
42

43
44 Size communications and other low-voltage systems raceways as follows:

45
46 Communications, including Equipment Outlet Box: 1 inch minimum. Conduit used for single device
47 locations (e.g. Wireless Access Point, Video Surveillance Camera, and Wall mounted telephone)
48 may be 3/4 inch minimum.
49

50 Control, security, signal, and other low-voltage applications (not including AV): 1/2 inch minimum.
51

52
53
54
55 Provide one raceway from each communications outlet box to cable tray.

56
57 Arrange conduit to maintain 6'-8" clear headroom and present a neat appearance.

58
59 Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent
60 piping.
61

62 Maintain minimum 6 inch (150 mm) clearance between conduit and piping. Maintain 12 inch (300 mm)
63 clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
64

- 1 Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using
2 galvanized pipe straps, conduit racks (lay-in adjustable hangers), clevis hangers, or bolted split stamped
3 galvanized hangers.
4
- 5 Group conduit in parallel runs where practical and use conduit rack (lay-in adjustable hangers) constructed
6 of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.
7
- 8 Do not fasten conduit with wire or perforated pipe straps. Before conductors are pulled, remove all wire used
9 for temporary conduit support during construction.
10
- 11 Support and fasten metal conduit at a maximum of 8 feet (2.4 m) on center.
12
- 13 Supports shall be independent of the installations of other trades, e.g. ceiling support wires, HVAC pipes,
14 other conduits, etc., unless so approved or detailed.
15
- 16 Conceal all conduits except where noted on the drawings or approved by the Architect/Engineer. Contractor
17 shall verify with Architect/Engineer all surface conduit installations except in mechanical rooms.
18
- 19 Changes in direction shall be made with symmetrical bends, cast steel boxes, stamped metal boxes or cast
20 steel conduit bodies.
21
- 22 For indoor and exposed exterior conduits, no continuous conduit run shall exceed 100 feet (30 meters)
23 without a junction box.
24
- 25 For exterior below grade conduits, no continuous conduit run shall exceed 250 feet (75 meters) without hand
26 hole, manhole or pull box without project specific DFDM electrical inspector approval.
27
- 28 All conduits installed in exposed areas shall be installed with a box offset before entering box.
29
- 30 **CONDUIT INSTALLATION**
- 31 Cut conduit square; de-burr cut ends.
32
- 33 Conduit shall not be fastened to the corrugated metal roof deck nor drywall or suspended ceiling grids.
34 Bring conduit to the shoulder of fittings and couplings and fasten securely.
35
- 36 Use conduit hubs for fastening conduit to cast boxes. Use sealing locknuts or conduit hubs for fastening
37 conduit to sheet metal boxes in damp or wet locations.
38
- 39 Threads cut in the field, and factory threads of conduit and nipples not coated with corrosion protection, shall
40 be coated with an approved electrically conductive compound per NEC 300.6.
41
- 42 Corrosion inhibitor, when used in the food service environment, shall be approved for Food Service locations.
43
- 44 Terminate all conduit (except for terminations into conduit bodies) using conduit hubs, or connectors with
45 one locknut, or utilize double locknuts (one each side of box wall).
46
- 47 Provide bushings for the ends of all conduit not terminated in box walls. Refer to Section 26 05 26 –
48 Grounding and Bonding for Electrical Systems for grounding bushing requirements.
49
- 50 Provide insulated bushings where raceways contain 4 AWG or larger conductors.
51
- 52 Communication and Low Voltage systems conduits shall terminate in horizontal plane.
53
- 54 Use pendants supported from swivel hangers in exposed ceiling/ structure locations where necessary to mount
55 boxes supporting luminaires and wiring devices. Installation method shall comply with NEC 314.23 (H).
56
- 57 Install no more than the equivalent of the following for building:
58
- 59 Three 90 degree bends between boxes for electrical systems.
 - 60
 - 61 Two 90 degree bends between boxes for communications and other low voltage systems. Note:
62 Offsets shall be considered 90 degrees.
 - 63
 - 64 No single bend may exceed 90 degrees.

1
2 Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2 inch (50 mm) size
3 unless sweep elbows are required.
4
5 Bend conduit according to manufacturer's recommendations. Torches or open flame shall not be used to aid
6 in bending of PVC conduit.
7
8 Use suitable conduit caps or other approved seals to protect installed conduit against entrance of dirt and
9 moisture.
10
11 Provide 1/8 inch (3 mm) nylon pull string in empty conduit, except sleeves and nipples.
12
13 Install listed expansion-deflection fitting or other approved means shall be used where a raceway crosses a
14 structural joint for expansion, contraction or deflection, used in buildings, bridges, parking garages or other
15 structure.
16
17 **Install expansion joints where direct-buried conduit is subject to Earth Movement by settlement or**
18 **frost per NEC 300.5(J), especially where conduit exits the ground exposed and enters a box, cabinet,**
19 **or enclosure attached to a building or structure.**
20
21 Install expansion fitting in exterior PVC conduit runs per NEC table 352.44 utilizing a minimum temperature
22 change of 120 degree F.
23
24 Avoid moisture traps where possible. Where moisture traps are unavoidable, provide junction boxes with
25 drain fittings at conduit low points.
26
27 Where conduit passes between areas of differing temperatures such as into or out of cool rooms, freezers,
28 unheated and heated spaces, buildings, etc., provide conduit or box with duct seal or other means to prevent
29 the passage of moisture and water vapor through the conduit.
30
31 Route conduit through roof openings for piping and ductwork where possible.
32
33 Where communication cabling is to be installed in conduit to the wiring hub (e.g. Telecom Room), multiple
34 conduits may be consolidated into fewer, larger conduits. Capacity of shared conduits shall equal the capacity
35 of the individual conduits unless otherwise noted.
36
37 Use NRTL listed metallic grounding clamps when terminating conduit to cable tray.
38
39 Ground and bond conduit under provisions of Section 26 05 26.
40
41 Conduit is not permitted in any slab topping of two inches (50 mm) or less.
42
43 Conduits in Concrete Slab Above Grade: Provide proposed conduit routing and sizing to Structural Engineer
44 for approval prior to installation to verify structural integrity and fire rating of concrete slab.
45
46 Maximum Size Conduit in Concrete Slabs Above Grade: 1 inch (25 mm). Do not route conduits to cross each
47 other in slabs above grade. Minimum conduit spacing shall be 6 inches on center.
48
49 PVC conduit shall transition to galvanized rigid metal conduit before it enters a foundation wall or up through
50 a concrete floor.
51
52 PVC conduit shall be allowed without need of transition to galvanized rigid metal conduit up through
53 concrete floor and concrete equipment pads for pad mounted transformers and switchgear. Provide a PVC
54 connector and bushing, or bell-ends, on each conduit entry. Coordinate conduit installation with submittals
55 and shop drawings for transformers and switchgear.
56
57 PVC conduits installed in exposed parking ramps shall have expansion fittings installed per NEC table
58 352.44, utilizing a minimum temperature change of 110 degrees F. Each conduit run shall be provided with
59 a minimum of one expansion fitting. Proper PVC clamps shall be utilized to allow for conduit movement.
60
61 Identify conduit under provisions of Section 26 05 53.
62
63 All Aluminum conduits shall not be in direct contact with concrete.
64

1 All conduit installed underground (exterior to building) shall be buried a minimum of 24 inches below
2 finished grade, whether or not the conduit is concrete encased. Install warning tape 12" below finish grade
3 over all buried conduits. Underground warning tape shall be detectable, 2" wide minimum, 5 mil thickness,
4 containing a foil core. Tape color shall be red and labeled with the words "CAUTION-BURIED ELECTRIC
5 LINE BELOW" as manufactured by Presco or similar.
6

7 **Conduits penetrating underground foundation walls: Individual conduits or each conduit as part of a**
8 **ductbank penetrating underground foundation walls (excluding manholes) shall be sealed against**
9 **water intrusion into the building.**

10
11 Clean PVC conduit with solvent, and dry before application of glue. The temperature rating of glue/cement
12 shall match weather conditions. Apply full even coat of cement/glue to entire area that will be inserted into
13 fitting. The entire installation shall meet manufacturer's recommendations.
14

15 **CONDUIT INSTALLATION SCHEDULE**

16
17 Conduit other than that specified below for specific applications shall not be used.

- 18 • Horizontal Directional Drilling (Directional Boring) Installations: HDPE conduit.
- 19
- 20
- 21 • Underground Installations That Penetrate Foundation Walls: Rigid metal conduit within five
22 feet (1.5 m) of the foundation wall. Conduit may transition to Fiberglass Resin Conduit (BG)
23 or PVC conduit five feet (1.5 m) from the foundation walls.
- 24
- 25 • Underground Installations That Do Not Penetrate Foundation Walls: Rigid metal conduit,
26 Fiberglass Resin Conduit (BG), or PVC conduit.
- 27
- 28 • Underground Installations Emerging from Grade: Buried conduit emerging from grade shall be
29 Rigid metal conduit extending from the minimum cover distance of 24 inches below grade to
30 the conduit termination point above grade. Refer to DFD detail.
- 31
- 32 • Underground Installations Under Concrete Slab: Rigid metal conduit or Schedule 40 PVC
33 conduit.
- 34
- 35 • Underground Installations Emerging through Concrete Slab: Rigid metal conduit.
- 36
- 37 • Concealed in Poured Concrete Walls: Rigid Metal Conduit, PVC conduit, or Electrical
38 Nonmetallic Tubing (ENT).
- 39
- 40 • Exposed Outdoor Locations: Rigid Metal conduit, Intermediate Metal conduit.
- 41
- 42 • Exposed within Parking Structures: Rigid Metal conduit, Intermediate Metal conduit, PVC
43 conduit.
- 44
- 45 • Concealed Dry Interior Locations: Rigid metal conduit, Intermediate metal conduit, Electrical
46 metallic tubing, PVC conduit (Ground conductor).
- 47
- 48 • Interior Building Grounding Electrode Conductor: Schedule 80 PVC.
- 49
- 50 • Exposed Dry Interior Locations: Rigid metal conduit, Intermediate metal conduit, Electrical
51 metallic tubing.
- 52
- 53 • Motor and equipment connections: Liquidtight flexible metal conduit (LFMC) in all locations
54 except in Mechanical equipment plenum spaces where Flexible Metal Conduit (FMC) shall be
55 utilized. Minimum length shall be one foot (300 mm); maximum length shall be three feet (900
56 mm). Conduit must be installed perpendicular to direction of equipment vibration to allow
57 conduit to freely flex.
- 58
- 59 • Exposed Dry Interior Locations for HVAC control devices with Conduit Connections:
60 Electrical metallic tubing, Flexible Metal Conduit (FMC). For FMC installations, Minimum
61 length shall be one foot (300 mm), Maximum length shall be three feet (900 mm). Minimum
62 size FMC of 3/8".

- 1 • Exposed Dry Interior Locations for HVAC control devices without Conduit Connections:
2 Where HVAC equipment control panels or devices do not provide for the direct connection of
3 conduits, exposed Class 2 wiring may be extended to complete the final connections in dry
4 locations, provided it does not exceed 18 inches in length.
- 5
- 6 • Light fixtures: Refer to specification section 26 51 13.
- 7
- 8 • Plenum Spaces: Installation shall comply with requirements of NEC 300.22.
- 9
- 10 • Medium Voltage Applications (Interior Locations): Rigid metal conduit (RMC).
- 11

12 **PVC COATED RIGID METAL CONDUIT INSTALLATION**

13 Installers of PVC Coated Rigid Metal Conduit shall be factory trained and certified in the proper installation
14 methods for this type of conduit. Proof of such certification shall be kept on the project site at all times and
15 shall be produced upon request.

16

17 **HIGH DENSITY POLYETHYLENE CONDUIT (HDPE) INSTALLATION**

18 See specification Section 26 05 34 -- Underground HDPE Pathways for Electrical Systems

19

20 **SURFACE METAL RACEWAY AND MULTI-OUTLET ASSEMBLY INSTALLATION**

21 Use flat-head screws to fasten channel to surfaces every twenty-four (24) inches. Mount plumb and level.

22

23 Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

24

25 Maintain grounding continuity between raceway components to provide a continuous grounding path under
26 provisions of Section 26 05 26.

27

28 Fastener Option: Use clips and straps suitable for the purpose.

29

30 **NONMETALLIC SURFACE RACEWAY INSTALLATION**

31 Use flat headed screws with appropriate anchors to fasten channel to surfaces secured every twenty-four (24)
32 inches. Mount plumb and level. All surface mounted devices shall be fastened to the wall utilizing flat head
33 screws along with appropriate anchors. No device shall be adhered to the wall surface using two-faced tape
34 or any means other than as described above.

35

36 Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

37

38 In areas where the walls cannot be fished, the station cable serving these outlets shall be covered with
39 raceways. No exposed wire shall be permitted within offices, laboratories, and conference rooms or like
40 facilities.

41

42 Non-metallic raceway shall have a screw applied base. Both the base and cover shall be manufactured of
43 rigid PVC materials.

44

45 The raceway shall originate from a surface mounted box mounted adjacent to and at the same height as
46 existing electrical boxes in the room, be attached to the wall and terminate above the ceiling.

47

48 All fittings including, but not limited to, extension boxes, elbows, tees, fixture bodies shall match the color
49 of the raceway.

50

51 The raceway and all systems devices shall be UL listed and exhibit nonflammable self-extinguishing
52 characteristics, tested to specifications of UL94V-0.

53

54 In raceway for communications and other low voltage systems, the inside bend radius minimum shall be as
55 follows:

- 56
- 57 • Internal diameter of 2 in or less- 6 times the internal diameter.
- 58 • Internal diameter of more than 2 in- 10 times the internal diameter.
- 59

60 Conduit bends shall contain no kinks or other discontinuities.

61

62 **COORDINATION OF BOX LOCATIONS**

63 Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment
64 connections, and code compliance.

1
2 Electrical box locations shown on Contract Drawings are approximate unless dimensioned. Verify location
3 of floor boxes and outlets in offices and work areas prior to rough-in.
4

5 No outlet, junction, or pull boxes shall be located where it will be obstructed by other equipment, piping,
6 lockers, benches, counters, etc.
7

8 Conduit and boxes shall not be fastened to the metal roof deck. If conduit and boxes are required to be located
9 and installed on roof decks, the conduit and boxes are required to be spaced minimum 1-5/8 inch off the
10 lowest part of the metal roof decking material, per NEC 300.4 (E).
11

12 It shall be the Contractor's responsibility to study drawings pertaining to other trades, to discuss location of
13 outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.
14

15 In case of any question or argument over the location of an outlet, the Contractor shall refer the matter to the
16 Architect/Engineer and install outlet as instructed by the Architect/Engineer.
17

18 The proper location of each outlet is considered a part of this contract and no additional compensation will
19 be paid to the Contractor for moving outlets which were improperly located.
20

21 Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and
22 provide 18 inch (450 mm) by 24 inch (600 mm) access doors. Boxes must be installed within 12" from edge
23 of the access door.
24

25 Locate and install to maintain headroom and to present a neat appearance.
26

27 Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and
28 methods.
29

30 Boxes installed in the building envelop shall be sealed with caulking materials or closed with gasketing
31 systems compatible with the construction materials and locations per IEC 502.4.3.
32

33 **PULL AND JUNCTION BOX INSTALLATION**

34 Pull boxes and junction boxes shall be minimum 4 inches square (100 mm) by 2 1/8 inches (54 mm) deep
35 for use with 1 inch (25 mm) conduit and smaller. On conduit systems using 1 1/4 inch (31.75 mm) conduit,
36 minimum junction box size shall be 4 11/16 inches square by 2 1/8 inches deep.
37

38 Where used with raceway(s) containing conductors of 4 AWG or larger, pull box shall be sized as required
39 unless otherwise noted on the drawings.
40

41 Where used with raceway(s) containing conductors on systems over 600V, size pull box per NEC 314 Part
42 IV unless otherwise noted as larger on the drawings.
43

44 Size pull boxes for communications per ANSI/TIA-568-C
45

46 Locate pull boxes and junction boxes above accessible ceilings, in unfinished areas or furnish and install
47 DFD approved access panels in non-accessible ceilings where boxes are installed. All boxes are to be readily-
48 accessible.
49

50 Provide Pull and Junction boxes for communications and other low voltage applications (a) in any section of
51 conduit longer than 100 feet, (b) where there are bends totaling more than 180 degrees between pull points
52 or pull boxes and (c) wherever there is a reverse bend in run. Locate boxes on straight section of raceway
53 (e.g. do not use boxes in place of raceway bends).
54

55 Support pull and junction boxes independent of conduit.
56

57 **IN GRADE HANDHOLES AND BOXES**

58 Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting
59 conduits to minimize bends and deflections required for proper entrances.
60

61 Unless otherwise indicated and detailed, support units on a level bed of crushed stone or gravel, graded
62 from 1/2 inch (12.5 mm) sieve to No. 4 (4.25 mm) sieve and compacted to same density as adjacent
63 undisturbed earth.

1
2 Elevation: In finished areas, set so cover surface will be flush with finished grade.
3
4 Unless approved by DFD review staff, handholes and boxes shall **NOT** be installed in paved or concrete
5 drives or walks.
6
7 Units shall be selected with depth sufficient to allow for conductor bending/ wire management and allow
8 sufficient conduit elevation above compacted bed to prevent water infiltration in conduit.
9
10 Provide four (4) sets of the tool(s) required to access tamper resistant locking covers. In addition, provide the
11 tool(s) model number to allow for ordering of additional sets. Tools and bits, shall be turned over to owners
12 representative, prior to project closeout.
13
14 Provide conduit sealant to seal conduits against water and gas intrusion, such as Polywater® FST™-250
15 Foam Duct Sealant, Raychem RDSS Rayplate Duct Sealing System, or approved alternate. Sealant shall be
16 re-enterable, shall be compatible with the conduit and conductor types being used, and shall comply with
17 NEC 225.27, 230.8, and 300.5(G).
18
19 **OUTLET BOX INSTALLATION**
20 Do not install boxes back-to-back in walls. Provide minimum 6 inch (150 mm) separation, except provide
21 minimum 24 inch (600 mm) separation in acoustic-rated walls.
22
23 Power:
24 Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction, or drywall shall
25 be minimum 4 inch square, with device rings. Device covers shall be square-cut except rounded
26 corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted.
27 Coordinate masonry cutting to achieve neat openings for boxes. A single gang box can be used in
28 drywall and masonry, for a single device location, when a single conduit enters box.
29
30 Shallow 4 inch square by 1 1/2 inch deep boxes can be used as device boxes for power provided the
31 box and plaster ring is sized for installed device and conductors.
32
33 Low Voltage:
34
35 Recessed (1/4 inch maximum) outlet boxes in masonry, concrete, tile construction or drywall shall
36 be minimum 4 11/16 inch square by 2 1/8 inch deep with single gang device ring (unless noted
37 otherwise on drawings or in companion specifications). Device covers shall be square-cut except
38 rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not
39 permitted. Coordinate masonry cutting to achieve neat openings for boxes.
40
41 Provide one conduit from each communications Equipment Outlet box. Conduit runs between outlet
42 boxes for communications are not allowed. Terminate conduit on cable tray.
43
44 Provide knockout closures for unused openings.
45
46 Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits,
47 both supported within 12 inches (300 mm) of box.
48
49 Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes.
50 Sectional boxes may only be used with the pre-approval of the State of Wisconsin DFD Electrical Inspector
51 for remodeling applications where it is impractical to install multi-gang boxes. Provide non-metallic barriers
52 to separate wiring of different voltage systems.
53
54 Install boxes in walls without damaging wall insulation.
55
56 Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
57
58 Ceiling outlets shall be 4 inch square, minimum 2 1/8 inch (54 mm) deep except that concrete boxes and
59 plates will be approved where applicable. Position outlets to locate luminaires as shown on reflected ceiling
60 plans.
61
62 In inaccessible ceiling areas, position outlets and junction boxes within 6 inches (150 mm) of recessed
63 luminaire, to be accessible through luminaire ceiling opening.

- 1 Provide written drilling plan outlining proposed equipment and construction methods, including the
2 following:
- 3 • Detailed description of the procedures including construction techniques to provide the access required
4 to install the pipeline
 - 5 • Dimensioned drawings of any proposed changes in the pipe alignment or profile
 - 6 • Literature describing in detail the drilling system to be used, including drill steering and locating system.
 - 7 • Drawings showing: Layout of boring and receiving locations and associated equipment at each location,
8 grade and alignment control system details, groundwater control provision of drilling equipment.
 - 9 • Qualifications and experience record of the drilling superintendent and machine operators.
 - 10 • Drilling fluid generation and management

11
12 Provide a directional drilling contingency plan that accounts for the following:

- 13 • Unforeseen obstructions that stop or delay the progress of drilling equipment
- 14 • Deviation from planned line and grade in excess of allowable tolerances
- 15 • Loss of drilling fluid
- 16 • Damage to other utilities
- 17 • Soil settlement or heaving

18
19 Provide written copies of quality assurance test results and reports performed by or for the contractor.
20

21 Within 48 hours of completing the pilot hole for each run of pipe, provide the log of the drilling operation
22 and guidance system records documenting the line and grade of that pilot hole to the DFD Construction
23 Representative and the AE. Note the location of any utilities or difficult drilling that was encountered.
24

25 **AS-BUILT DOCUMENTS**

26 Provide printed record of actual horizontal and vertical location of installed pipe from borehole survey
27 instrumentation in addition to marked up drawings.
28

29

30

31 **PART 2 - PRODUCTS**

32

33 **CONDUIT, FITTINGS AND SPLICES**

34 **Conduit**

35 Schedule 80

36

37 Continuous length smooth-wall HDPE conduit for electrical applications per ASTM F2160.

38

39 Conduit shall be listed by a Nationally Recognized Testing Laboratory (NRTL).

40

41 Color:

- 42 • Power – Black or Black with red stripes.
- 43 • Communications -- Orange

44

45 **Fittings and Splices**

46 See PART 3.

Couplings and Fittings shall be listed.

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Marking

Each length of pipe and each fitting shall be clearly and durably marked on their outer surface with their manufacturing details.

Marking shall include Material Type, listing and the date of manufacture.

Fittings shall be clearly and durably marked, including manufacturer’s name or trademark, material type, class of pipe, listing and a date or code of manufacture..

Spacing of labeling on pipe shall not exceed 10-feet.

TRACER WIRE

Tracer wire shall be #10 stainless steel wire with 45 mil HDPE jacket.

Alternately, tracer wire may be embedded in conduit wall.

DRILLING FLUID

ANSI/NSF 60 (Drinking Water Treatment Chemicals – Health Effects) certified bentonite-based drilling fluid.

PART 3 - EXECUTION

GENERAL

Comply with the requirements of applicable specification sections for the utility line being installed.

Conduct any necessary field surveys, subsurface investigations and geotechnical investigations necessary to complete the work.

Locate all known utilities located adjacent to or crossing the utility line being installed. Excavate to expose utilities prior to initiating drilling and as required to verify applicable clearances. Clearance shall meet applicable code requirements and the requirements of the directional drilling process.

Locate and verify the clearance of known structures and foundations/footings located adjacent to or crossing the utility line being installed.

EXCAVATION, BACKFILL AND COMPACTION

Excavate insertion and receiving pits, and other access points as necessary to complete the work.

1 **CONDUIT INSTALLATION**

2 HDPE conduit may only be used in horizontal directional drilling applications. Installation must be in
3 accordance with NFPA 70 National Electrical Code and be direct buried or encased in concrete.

4
5 HDPE shall not be routed such that it is exposed above grade.

6
7 Storage and handling of polyethylene pipe shall not result in damage to or deformation of the pipe. Protect
8 polyethylene pipe from long-term exposure to temperature fluctuations and sunlight.

9
10 Prepare pipe on a relatively smooth surface, free of sharp rocks, sticks, or debris. Utilize cribbing, pipe
11 stands, rollers, or other equipment as necessary to support the pipe.

12
13 Lift and move piping using ropes, slings, or straps. Do not use unprotected chains, hooks, or clamps to lift
14 pipe.

15
16 When lifting and moving pipe, provide a minimum of two points of support. Do not support pipes at butt-
17 fused joints.

18
19 Sections of pipes with cuts and gouges exceeding 10 percent of the pipe wall thickness or kinked sections
20 shall be removed and rejoined at the Contractor's expense.

21
22 Plug all pipes at end of each workday. Provide a watertight plug to prevent entry of foreign materials into
23 the pipe.

24
25 **DRILLING**

26 Drilling methods shall generally consist of drilling a pilot hole the length of the bore, followed by reaming
27 and pullback of the pipeline. Ream borehole multiple times, as necessary. The equipment and methods
28 used to complete the bore and install piping shall be determined by the Contractor, but subject to the
29 Contract Documents.

30
31 The drill staging area shall be kept neat and orderly and disturb as little area as possible. The pipe staging
32 area shall disturb as little area as needed to accommodate workers and equipment, and to string, fuse, and
33 inspect the pipe.

34
35 Install all pulleys, rollers, bumpers, alignment control devices and other equipment required to support and
36 protect the new pipe from damage during installation.

37
38 Utilize a drilling fluid cleaning/recycling system. Entry and exit pits shall be sized and constructed to
39 completely contain drilling fluid.

40
41 Install boring to line and grade shown on drawings. Alignment shall be within tolerances specified in
42 applicable utility specification sections.

1 Borehole survey instrumentation shall be used to monitor line and grade of the pilot hole. Contractor shall
2 maintain records documenting the line and grade of the pilot hole.

3

4 Contractor shall notify the DFD Project Representative upon completion of the pilot hole to observe
5 alignment prior to reaming and pullback.

6

7 **JOINING PIPE**

8 Joints between lengths of conduit and between conduit and couplings, fittings and boxes shall be by an
9 approved method using either Heat Fusion, Electrofusion or listed Mechanical Fittings. Glue and/or solvents
10 are NOT approved.

11

12 Any joining method employed shall be in accordance with manufacturer recommendations.

13

14 The tensile strength at yield of the butt-fusion joints shall not be less than the pipe.

15

16 **REAM AND PULLBACK**

17 Back-ream Pilot hole reamed to accommodate pipe. Select reamer size and number of passes required.

18

19 Pull pipe back using swivel to prevent torsion of pipe.

20

21 Monitor tension forces on pipe during pullback. Do not exceed maximum stresses recommended by the
22 pipe supplier.

23

24 Support pipeline during pullback operations. Provide supports/rollers in accordance with manufacturer's
25 recommendations. Supports and rollers shall allow for free movement of the pipeline and prevent damage
26 to the pipe.

27

28 Use a drilling fluid in conjunction with the installation of the pipe to fill the annular space around the
29 installed pipeline. Contractor is responsible for determining the type of fluid to use.

30

31 Properly dispose all excess drilling fluid and slurry material recovered from the hole during drilling
32 operations and displaced by the pipe during installation.

33

34 Unless otherwise noted on the drawings, terminate and cap carrier pipe 5' above the proposed ground
35 surface.

36

37 **TRACER WIRE**

38 **General**

39 Install Tracer Wire (unless embedded in conduit wall) during pullback operations.

40

41 Terminate Tracer Wire at conduit end points and at all intermediate pull points in a fashion as to make it
42 available for locating.

43

1 Allow the manufacturer's recommended amount of time for cooling and relaxation due to tensile stressing
2 prior to connecting pipe to adjacent pipe sections, fittings, or structures, or backfilling of the insertion pit.
3 Provide sufficient excess length of new pipe at insertion pits to allow for cooling and relaxation.

4

5 **Continuity Testing:**

6 Test continuity of the Tracer Wire using an ohmmeter prior to demobilizing.

7

8 Tracer Wire Resistance shall be no greater than 105% of the specified unit resistance times installed length.

9

10 Conduct testing in the presence of the DFD Project Representative unless this requirement is waived.

11

12 Provide a written report describing equipment used, test methods, and detailed test results.

13

14 In the event of a failed test, make all necessary repairs required to provide a tracer wire system that
15 complies with the performance requirements of this section.

16

17

18

END OF SECTION

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SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

The work under this section includes the requirements relating to the furnishing and installation of Identification for Electrical Systems. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- Submittals

PART 2 - PRODUCTS

- Materials

PART 3 - EXECUTION

- General
- Box Identification
- Communication Conduit Labeling
- Power, Control and Signal Wire Identification
- Wiring Device Identification
- Support Wire Identification
- Nameplate Engraving for Electrical Equipment
- Panelboard Directories

RELATED WORK

Applicable provisions of Division 1 shall govern work under this section.

Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

Section 26 05 23 – Control-Voltage Electrical Power Cables

Section 01 91 01 or 01 91 02 – Commissioning Process

SUBMITTALS

Include schedule for nameplates.

Prior to installation, the contractor shall provide samples of all label types planned for the project. These samples shall include examples of the lettering to be used. Samples shall be mounted on 8 1/2" x 11" sheets, explaining their purposed use.

PART 2 - PRODUCTS

MATERIALS

Labels: All labels shall be permanent, and machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS ARE ALLOWED.

Wire Labels: All wiring labels shall be white/transparent nylon or vinyl, self-laminating, wraparound type. Flag type labels are not allowed. The labels shall be of adequate size to accommodate the circumference of the cable being labeled and properly self-laminate over the full extent of the printed area of the label.

Tape (wiring phase identification only): Scotch #35 tape in appropriate colors for system voltage and phase. Embossed tape shall not be permitted for any application.

Nameplates: Engraved multi-layer laminated plastic. See Electrical Equipment Identification in the Execution section for nameplate color and size requirements.

See Box Identification and Wiring Device Identification sections for allowed usage of permanent marker.

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PART 3 - EXECUTION

GENERAL

Clean all surfaces before attaching labels with the label manufacturer's recommended cleaning agent. Install all labels firmly as recommended by the label manufacturer. Labels shall be installed plumb and neatly on all equipment.

Install nameplates parallel to equipment lines. Secure nameplates to equipment fronts using screws, rivets or manufacturer approved adhesive or cement.

Provide all warning labels to electrical equipment as required per NEC 110.16 and 110.21. Provide available fault current labeling to service equipment as required per NEC 110.24.

Provide a sign at the service-entrance equipment indicating type and location of on-site emergency power sources and on-site legally required standby power sources, per NEC 700.7 and NEC 701.7.

Fire pump disconnecting means shall be identified as "Fire Pump Disconnecting Means", per NEC 695.4(B)(3)(c).

Provide a sign at each service disconnect indicating "Service Disconnect", per NEC 230.70(B).

Emergency circuits shall be permanently marked so they will be readily identified as a component of an emergency system per NEC 700.10(A)(2). Identification shall be made by the following methods:

1. All boxes and enclosures shall be permanently identified by box color(s) or nameplate(s) as indicated under the headings Box Identification or Electrical Equipment Identification below.
2. Where boxes or enclosures are not encountered, exposed cable or raceway shall be labeled as described under the heading Wire Labels above. Wire Labels shall be color coded as defined under the heading Box Identification below. Labels shall be applied at intervals not to exceed 7.6 m (25 ft).

BOX IDENTIFICATION

All junction and pull boxes shall be identified by color, based on the following color scheme:

Power Systems	Color(s)
Secondary Power – 480Y/277V	Brown
Secondary Power – 208Y/120V, 240/120V	White
Emergency (NEC 700) – 480Y/277V	Brown/Red
Emergency (NEC 700) – 208Y/120V	White/Red
Legally Required Standby (NEC 701) – 480Y/277V	Brown/Blue
Legally Required Standby (NEC 701) – 208Y/120V	White/Blue
Optional Standby (NEC 702) – 480Y/277V	Brown/Yellow
Optional Standby (NEC 702) – 208Y/120V	Black/Yellow
Other Systems	Color(s)
Fire Alarm	Red
Temperature Control	Green
Door Access Control	Orange
Sound and Intercom Systems	Gray
Video Surveillance System	Yellow
Communications	Blue
Lighting Control 0-10VDC	Purple

Other Systems not identified above, boxes shall be left in natural finish and be further identified as shown on drawings or approved shop drawings.

The means of junction and pull box identification shall be as follows:

1. Boxes 8" Square or Smaller – Concealed (Above Accessible Ceilings).

- 1 • Color identified utilizing fully painted covers. If box contains power wiring, the box
- 2 shall be further identified with circuit numbers and source panel designation, using
- 3 machine-generated adhesive label or neatly hand-written permanent marker.
- 4 2. Boxes 8” Square or Smaller – Exposed.
- 5 • Color identified utilizing fully painted covers. If box contains power wiring, the box
- 6 shall be further identified with circuit numbers and source panel designation, using
- 7 machine-generated adhesive label or engraved nameplate.
- 8 3. Boxes Larger than 8” Square – Concealed (Above Accessible Ceilings).
- 9 • Color identified utilizing 4” x 4” minimum-sized painted patch, or color-correct machine-
- 10 generated adhesive label. If box contains power wiring, the box shall be further
- 11 identified with circuit numbers and source panel designation using machine-generated
- 12 adhesive label or neatly hand-written permanent marker. Letter height shall be ½”
- 13 minimum.
- 14 4. Boxes Larger than 8” Square – Exposed.
- 15 • Color identified utilizing 4” x 4” minimum-sized painted patch, or color-correct engraved
- 16 nameplate. If box contains power wiring, the box shall be further identified with circuit
- 17 numbers and source panel designation using engraved nameplate. Letter height shall be
- 18 ½” minimum.
- 19

20 All fire alarm boxes (covers and outer sides) shall be painted red and labeled “Fire Alarm” or “FA”. When

21 red conduit is used for the alarm system installation, there is no need to paint the box sides, - paint the

22 covers only. Non-factory device boxes shall also be painted red.

23

24 **COMMUNICATIONS CONDUIT LABELING**

25 Provide label on all conduits installed between Telecommunication Equipment Rooms. Both ends of the

26 conduits shall be labeled. All labels shall be mechanical, no hand-written labels.

27 The label shall indicate the location of the far end of the conduit run and a unique conduit number. (i.e. TR-

28 1A-01 or Room #216 – 01). Refer to agency standards where applicable.

30

31 **POWER, CONTROL AND SIGNALING WIRE IDENTIFICATION**

32 Provide wire labels on each conductor in panelboard gutters, all boxes, and at load connection. Identify with

33 branch circuit or feeder number for power and lighting circuits, and with wire number as indicated on

34 schematic and interconnection diagrams or equipment manufacturer's shop drawings for control and signaling

35 wires.

36

37 All wiring shall be labeled within 2 to 4 inches of terminations. Each end of a wire or cable shall be labeled

38 as soon as it is terminated, including wiring used for temporary purposes.

39

40 **WIRING DEVICE IDENTIFICATION**

41 Wall switches, receptacles, occupancy sensors, photocells, poke-through fittings, access floor boxes, and

42 time clocks shall be identified with circuit numbers and panelboard source (ex. Panel ABC-3). In exposed

43 areas, identifications should be made inside of device covers, unless directed otherwise. Use machine-

44 generated adhesive labels, or neatly hand-written permanent marker.

45

46 **SUPPORT WIRE IDENTIFICATION**

47 Support wires that are installed in addition to the ceiling grid support wires to provide secure support for

48 raceways, cables assemblies, boxes, cabinets, and fittings shall be distinguishable from the ceiling grid

49 support wires per NEC 300.11(A). This identification shall be either approximately 6 inches of fluorescent

50 orange paint, or orange tape flags 3/4 inches high-by-2 inches wide (minimum) within 12 inches of the bottom

51 of the support wires.

52

53 **ELECTRICAL EQUIPMENT IDENTIFICATION**

54 Nameplates for all panelboards, circuit breakers, disconnect switches, and transformers shall be based on

55 the following color scheme:

56

57 Power Systems	58 Color(s)
59 Secondary Power – 480Y/277V	White letters on Brown background
60 Secondary Power – 208Y/120V, 240/120V	Black letters on White background
61 Emergency (NEC 700) – 480Y/277V	Brown letters on Red background
62 Emergency (NEC 700) – 208Y/120V	White letters on Red background
63 Legally Required Standby (NEC 701) – 480Y/277V	Brown letters on Blue background

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- 1 Legally Required Standby (NEC 701) – 208Y/120V White letters on Blue background
2
3 Optional Standby (NEC 702) – 480Y/277V Brown letters on Yellow background
4 Optional Standby (NEC 702) – 208Y/120V Black letters on Yellow background
5
6 Provide nameplates of minimum letter height as scheduled below:
7 All Panelboards (Distribution, Branch, Sub-feed, and Feed-Through), Switchboards and Motor Control
8 Centers: 1 inch (25 mm); identify equipment designation (same designation used by the main distribution
9 center). 1/2 inch (13 mm); identify voltage rating, source and room location of the source.
10
11 Panelboards serving NEC 700, 701 or 702 loads shall identify which branch they serve.
12
13 Both panels in a double tub application shall be labeled.
14
15 Circuit Breakers, Switches, and Motor Starters in Distribution Panelboards, Switchboards and Motor Control
16 Centers: 1/2 inch (13 mm); identify circuit number and load served, including location.
17
18 **PANELBOARD DIRECTORIES**
19 Typed directories for panelboards shall be covered with clear plastic and shall have a metal frame. Room
20 number on directories shall be Owner's numbers, not Plan numbers unless Owner so specifies.
21
22
23

END OF SECTION

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SECTION 26 08 00
COMMISSIONING OF ELECTRICAL
BASED ON DFD MASTER SPECIFICATION DATED 03/01/21

PART 1 - GENERAL

SCOPE

This section includes commissioning forms for construction verification and functional performance testing. Included are the following topics:

PART 1 - GENERAL

Scope

Related Work

Reference

Submittals

PART 2 - PRODUCTS

(Not Used)

PART 3 – EXECUTION

Commissioning Forms

CV-26 05 19 Low-Voltage Electrical Power Conductors and Cables

CV-26 05 26 Grounding and Bonding for Electrical Systems

CV-26 05 33 Raceways and Boxes for Electrical Systems

CV-26 24 16 Panelboards

CV-26 28 16 Enclosed Switches and Circuit Breakers

CV-26 51 13 Interior Lighting Fixtures, Lamps and Ballasts

RELATED WORK

Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCE

Applicable provisions of Division 1 shall govern work under this section.

SUBMITTALS

Reference the General Conditions of the Contract for submittal requirements.

Reference Section 01 91 01 or 01 91 02 Commissioning Process for Construction Verification Checklist and Functional Performance Test submittal requirements.

PART 2 – PRODUCTS

(Not Used)

PART 3 – EXECUTION

COMMISSIONING FORMS

Commissioning forms are to be filled in as work progresses by the individuals responsible for installation and shall be completed for each installation phase.

Provide a description of the work completed since the last entry, the percentage of the total work completed for the system for that area and the step of installation or finalization.

Circle Yes or No for each commissioning form item. If the information requested for an item does not apply to the given stage of installation for the system, list it as “N/A”. Explain all discrepancies, negative responses or N/A responses in the negative responses section.

- 1 Once the work is 100% complete and the responses to each item are complete and resolved for a given
- 2 commissioning forms group, mark as complete, initial and date in the spaces provided.
- 3
- 4 Provide copies of the commissioning forms to the commissioning agent 2 days prior to construction
- 5 progress meetings.
- 6
- 7

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

CV-26 05 19 – Low-Voltage Electrical Power Conductor and Cables

Equipment Identification/Tag: _____

Location: _____

A) CONDUCTOR AND CABLING PULLING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)						
				1)	2)	3)	4)	5)	6)	7)
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____			DATE: _____			

Question Details

- 1) Conductor and cabling sized to maintain less than a 3% voltage drop for rated length and ampacity of circuit.
- 2) Conductors and cabling coloring match specification requirements for given voltage, wire gauge, and leg of circuit.
- 3) Conduits swabbed to remove foreign material prior to pulling cables.
- 4) All cables pulled though conduit at the same time, with pulling lubricant used to ease pulling tensions.
- 5) Excess cable provided at each termination and splice point for purpose of multiple terminations or splices to be performed.
- 6) Emergency power conductors and cabling pulled in separate conduits from normal power systems.
- 7) Outdoor cables not to be terminated within 8 hours to be properly sealed and protected from moisture intrusion until termination.

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B) CONDUCTOR AND CABLE TERMINATIONS & SPLICES CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____				DATE: _____			

Question Details

- 1) Installed lugs match the pads on the equipment to which the cable will be mounted.
- 2) All lug terminations are connected per connection torque value as recommended by the manufacturer.
- 3) Splices made only in accessible junction boxes.
- 4) All conductors and cables cleaned prior to termination.
- 5) All splices made so that the electrical resistance of the splice does not exceed the equivalent resistance of 2' of conductor.
- 6) Solderless spring type pressure connectors with insulating covers used for all wires splices and taps of conductors and cabling 10AWG and smaller.
- 7) Mechanical or compression connectors used for all wire splices and taps of conductors and cabling 8 AWG and larger.
- 8) Uninsulated conductors and connectors taped with electrical tape equivalent to 150% of the insulation value of the conductor.

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

C) TESTING & FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
<input type="checkbox"/> CHECKLIST GROUP COMPLETE			INITIALS:						DATE:

Question Details

- 1) All exposed conductors and cabling has been visually inspected for physical damage and any damaged conductors and cabling has been replaced.
- 2) Conductors and cabling jacket and insulation are in good condition.
- 3) All cable terminations have been checked for proper tightness and clearances per specification and manufacturer recommendations and any adjustments necessary have been made.
- 4) For aluminum conductors and cabling all specified acceptance tests have been performed on all cables, terminations, and splices and are approved prior to energizing.
- 5) All splices and terminations are to be tagged within 2” to 4” of splice or termination and in accordance with specification requirements.

Construction Verification Checklist
26 05 19 – Low-Voltage Electrical Power Conductors and Cables

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 26 – Grounding and Bonding for Electrical Systems

CV-26 05 26 – Grounding and Bonding for Electrical Systems

Equipment Identification/Tag: _____
Location: _____

A) GENERAL GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	NO	
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____			DATE: _____						

Question Details

- 1) Mechanical connections accessible for inspection and checking, with no insulation of connections.
- 2) Ground connection surfaces cleaned and all connections made permanent.
- 3) Grounds attached permanently before permanent building service is energized.
- 4) Grounding electrode conductors installed in PVC conduit or rigid galvanized steel conduit and bonded at both ends to the grounding electrode conductor with an approved grounding fitting.
- 5) Grounding electrode is correct size and length.
- 6) Grounded conductor run to each service disconnecting means and its enclosure.
- 7) Separate insulated equipment grounding conductor installed with phase conductors within each raceway.
- 8) All metallic systems (water, gas, sprinkler, etc.) and lightning protection system bonded to ground system.
- 9) System bonded within 5' from point of entry into building to at least two of the following: metal underground water pipe, metal frame of building, concrete encased

Construction Verification Checklist
 26 05 26 – Grounding and Bonding for Electrical Systems

electrodes, ground ring, (underground local systems such as storage tanks, conduit, or piping), ground rod installed 8’ deep or at 45-degree angle and distanced a minimum of 6’ apart., ground plate buried 2-1/2’ deep.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 26 – Grounding and Bonding for Electrical Systems

B) MEDIUM VOLTAGE GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
				YES	YES	YES	YES	YES	YES	YES	YES	
				NO	NO	NO	NO	NO	NO	NO	NO	
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____				DATE: _____				

Question Details

- 1) Ground bus installed 18" above finished floor with insulated standoffs 36" on center, completely around the perimeter of the room (vault) containing the high voltage switchgear and unit substation.
- 2) Six ground rods provided equally spaced around high voltage switchgear room and connected to ground bus with 4/0 copper.
- 3) Separate 4/0 copper conductors provided from ground bus to, XO terminal of each transformer, each high voltage switch ground bus, and secondary service equipment ground bus.
- 4) Full size 600V copper THHN/THWN or XHHW-2 grounding conductor provided in each conduit, raceway or enclosure which contains high voltage conductors, and terminated at ground bus of equipment containing high voltage terminations.
- 5) Each enclosure containing high voltage parts (switches, fuses, transformers, pull boxes, etc.) bonded to room ground bus with 4/0 copper conductor.
- 6) All conduits containing high voltage conductors or secondary service conductors bonded to penetrated enclosures using grounding bushing and #4 copper conductor.
- 7) #10 stranded wire provided from each termination shield drain wire to ground bus within enclosure.
- 8) Ground rod provided in each section of each secondary switchboard with 4/0 copper wire connection to ground rod and to switchgear ground bus.

Construction Verification Checklist
26 05 26 – Grounding and Bonding for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 26 – Grounding and Bonding for Electrical Systems

C) LOW VOLTAGE (<600V) GROUNDING AND BONDING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
				YES	YES	YES	YES	YES	YES	YES			
				NO	NO	NO	NO	NO	NO	NO			
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____			DATE: _____						

Question Details

- 1) Code sized copper grounding electrode conductor provided from secondary switchboard ground bus, each separately derived system neutral, secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes.
- 2) Bonding jumper provided around water meter.
- 3) Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor bonded in raceways and cables, receptacle ground connectors, and plumbing systems.
- 4) Separate insulated equipment grounding conductor provided within each raceway.
- 5) Ground wire provided from each device to the respective enclosure.
- 6) Communications system grounding conductor provided at point of service entrance and connected to building common grounding electrode system.
- 7) Telecommunications and audio visual systems installed with an isolated grounding system with only one ground point at the electrical service entrance for the building per specification requirements.

Construction Verification Checklist
26 05 26 – Grounding and Bonding for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

CV-26 05 33 – Raceway and Boxes for Electrical Systems

Equipment Identification/Tag: _____

Location: _____

A) CONDUIT & FITTINGS PRE-INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)	
				1)	2)
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
				YES NO	YES NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____	
				DATE: _____	

Question Details

- 1) Conduit type and material in accordance with specification requirements for given application and location.
- 2) Conduit sufficiently sized to accommodate cabling and fill requirements of contract document.

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

B) CONDUIT & FITTINGS INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS:			DATE:						

Question Details

- 1) Conduit support spacing complies with specification requirements.
- 2) All conduit supported independently of piping, ductwork, equipment, cable tray or other conduit.
- 3) Bends in conduit minimized with required bends conforming to specification requirements and no more than an equivalent of three 90 degree bends between boxes.
- 4) Moisture traps are avoided as much as possible. When unavoidable, a junction box is provided with drain fitting at conduit low point.
- 5) All equipment requiring maintenance is accessible.
- 6) Minimum 6” clearance between conduit and piping, and 12” clearance between conduit and heat sources such as flues, steam pipes, and heating appliances is provided.
- 7) No continuous conduit run exceeds 100’ without a junction box.
- 8) Expansion-deflection joints installed where conduit crosses building expansion joints.
- 9) Where conduit passes between areas of differing temperatures, listed conduit seals are provided.
- 10) At end of work day suitable conduit caps or other approved seals provided for incomplete work to protect installed conduit against entrance of dirt and moisture.

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

C) RACEWAY & GUTTER INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)							
				1)	2)	3)	4)	5)	6)	7)	8)
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____				DATE: _____			

Question Details

- 1) Raceway and gutter support spacing and methods comply with specification requirements.
- 2) All raceways supported independently of piping, ductwork, equipment, cable tray or other conduit.
- 3) Suitable insulating bushings and inserts provided at connections to outlets and corner fittings.
- 4) All equipment requiring maintenance is accessible.
- 5) Expansion-deflection joints installed where conduit crosses building expansion joints.
- 6) Oil tight gutters included gaskets at each joint.
- 7) Rain-tight gutters are installed in horizontal position only.
- 8) At end of work day suitable caps or other approved seals provided for incomplete work to protect installed raceways and gutters against entrance of dirt and moisture.

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

D) JUNCTION, PULL AND OUTLET BOXES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)								
				1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____			DATE: _____					

Question Details

- 1) Boxes provided in locations as per contract documents, Engineer’s direction or as necessary for splicing and terminations.
- 2) Box type and material in accordance with specification requirements for given application and location.
- 3) No outlet box located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.
- 4) All boxes supported independently of conduit, piping, ductwork, equipment, or cable tray.
- 5) No outlet boxes installed back-to-back in walls, and minimum 6” separation between all boxes, except for installations in acoustic walls where a minimum 24” separation between boxes is provided.
- 6) All boxes are accessible, and where installation is inaccessible, 18” by 24” access door has been provided.
- 7) Mounting heights for outlet boxes corresponds with contract document requirements.
- 8) All recessed outlet boxes in finished areas are mounted to the correct depth to accommodate and be flush to final surface finish.
- 9) Knockout closures provided for unused openings.

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

E) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS:			DATE:						

Question Details

- 1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
- 2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
- 3) Conduits that penetrate the building envelope are sealed to prevent intrusion of air and moisture and are accessible.
- 4) All conduit junction boxes are painted and tagged in accordance with specification requirements.
- 5) All splices and terminations are to be tagged within 2” to 4” of splice or termination and in accordance with specification requirements.
- 6) 1/8” nylon pull string provided in all empty conduits, except sleeves and nipples.
- 7) Grounding and bonding of conduits and raceways conform to specification requirements.

Construction Verification Checklist
26 05 33 – Raceway and Boxes for Electrical Systems

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 24 16 – Panelboards

CV-26 24 16 – Panelboards

Equipment Identification/Tag: _____

Location: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>A</i>	<i>MODEL VERIFICATION</i>		
1	Manufacturer		
2	Model		
3	Catalog Number		
4	Voltage / Phase / Frequency (V / - /Hz)	/ /	/ /
5	Main Amps (A)		
6	Circuit Count		
7	kAIC rating (kA)		
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Response	
<i>B</i>	<i>PHYSICAL CHECKS</i>		
1	Unit is free from physical damage.	YES	NO
2	All components/accessories present.	YES	NO
3	Circuit breaker capacities documented.	YES	NO
4	Unit tags affixed.	YES	NO
5	Manufacturer's ratings readable/accurate.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>C</i>	<i>INSTALLATION</i>		
1	Unit secured as required by manufacture, specifications, and seismic zone requirements.	YES	NO
2	Adequate clearance around unit for service per table NEC-110.26.	YES	NO
3	Top of tub set at 6' from finished floor unless specified otherwise in contract documents.	YES	NO
4	Conduit feeds are aligned with openings and accommodate seismic motion.	YES	NO
5	Unit is level, plumb, and square.	YES	NO
6	Unit labeled and is easy to see.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>D</i>	<i>WIRING</i>		
1	Three spare ¾" empty conduits provided (recessed units ONLY).	YES	NO
2	Unit is adequately grounded to grounding lug for intended use.	YES	NO
3	Proper phasing has occurred in relationship to phase conductors.	YES	NO
4	All connections are terminated properly.	YES	NO
5	All electrical connections are tight.	YES	NO
6	All cables are permanently labeled relative to use.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>E</i>	<i>STARTUP</i>		
1	All protective coverings have been removed.	YES	NO
2	Unit has been cleaned of all debris and dirt on interior of unit.	YES	NO
3	Insulators and supports show no signs of damage or cracks.	YES	NO

Construction Verification Checklist
26 24 16 – Panelboards

Group/Item	Group/Task Description	Response	
4	Current transformers secured and wired per manufacturer instructions (metering applications ONLY).	YES	NO
5	All electronic circuit breaker settings have been adjusted to desired setting (if applicable).	YES	NO
6	Ground-fault-protection (GFP) trip and time delays have been adjusted to desired setting (if applicable).	YES	NO
7	All wiring connections verified for proper torques values and are acceptable.	YES	NO
8	Phase-to-phase, phase-to-ground, and neutral-to-ground, and dielectric tests have been accomplished and results are acceptable.	YES	NO
9	No hazards or adverse circumstances exist per continuity and high potential tests.	YES	NO
10	Insulation megger test accomplished and results acceptable.	YES	NO
11	Unit energized by authorized personnel.	YES	NO
12	All damage to unit finish is repaired.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____
<i>F</i> TESTING & FINALIZATION			
1	Overcurrent protective devices have been manually exercised.	YES	NO
2	Solid state circuit breaker self-diagnostics completed.	YES	NO
3	Electronic circuit breaker trip unit tests completed.	YES	NO
4	Ground-fault-protection (GFP) system tested and certified.	YES	NO
5	Filler plates provided for all unused spaces.	YES	NO
6	As-built circuit index provided and attached to interior of unit door.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Negative Responses

Group/Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

Construction Verification Checklist
26 28 16 – Enclosed Switches and Circuit Breakers

CV-26 28 16 – Enclosed Switches and Circuit Breakers

Equipment Identification/Tag: _____

Location: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>A</i>	<i>MODEL VERIFICATION</i>		
1	Manufacturer		
2	Model		
3	Serial Number		
4	Voltage (V)		
5	Ampere Rating (A)		
6	kAIC Rating (kA)		
7	Enclosure Type		
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Response	
<i>B</i>	<i>PHYSICAL CHECKS</i>		
1	Unit is free from physical damage.	YES	NO
2	All components/accessories present.	YES	NO
3	Unit tags affixed.	YES	NO
4	Manufacturer's ratings readable/accurate.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>C</i>	<i>INSTALLATION</i>		
1	Unit secured as required by manufacturer and specification requirements.	YES	NO
2	Adequate clearance around unit for service.	YES	NO
3	Conduit feeds are aligned with openings and accommodate seismic motion.	YES	NO
4	Unit is level, plumb, and square.	YES	NO
5	Unit labeled and is easy to see.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>D</i>	<i>WIRING</i>		
1	Unit is adequately grounded for intended use.	YES	NO
2	All connections are terminated properly.	YES	NO
3	All electrical connections are tight.	YES	NO
4	All cables are permanently labeled relative to use.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Group/Item	Group/Task Description	Submitted	Delivered
<i>E</i>	<i>STARTUP</i>		
1	Electronic circuit breaker settings have been adjusted to desired setting (if applicable).	YES	NO
2	Overcurrent protective devices have been manually exercised.	YES	NO
3	Electronic circuit breaker trip unit test completed.	YES	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE		INITIALS: _____	DATE: _____

Construction Verification Checklist
26 28 16 – Enclosed Switches and Circuit Breakers

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

CV-26 51 13 – Interior Light Fixtures, Lamps and Ballasts

Equipment Identification/Tag: _____

Location: _____

A) INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____				DATE: _____					

Question Details

- 1) Fixtures, ballasts, and lamps are free from damage.
- 2) Identical ballasts provided for each fixture type.
- 3) All fixtures and exit signs installed in locations specified in contract documents.
- 4) Fixtures do not impede access to other systems or equipment for maintenance.
- 5) Suspended fixtures and exit signs are hung independent of any other fixture, system, or equipment, are level, and are suspended with appropriate materials and methods defined within the contract documents.
- 6) Fixtures larger than 2'x4' or greater than 50 lbs. are supported independently from ceiling framing.
- 7) All recessed fixtures are installed flush to ceiling or wall finish.
- 8) All recessed fixtures are installed to permit removal and access to lamps from below.
- 9) All wall mounted fixtures and exit signs are mounted at heights specified in contract documents.

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

10) All fixtures are supported and installed in accordance with manufacturer and specification requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

B) WIRING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)					
				1)	2)	3)	4)	5)	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
				YES NO	YES NO	YES NO	YES NO	YES NO	
<input type="checkbox"/> CHECKLIST GROUP COMPLETE			INITIALS:						DATE:

Question Details

- 1) Fixture and accessories grounded and bonded to branch circuit grounding conductor.
- 2) Maximum of 6' of flexible conduit provided for lay-in, recessed fixtures.
- 3) All electrical connections are tight.
- 4) All conductors are labeled per specification requirements.

Negative Responses

Group/Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

C) STARTUP & TESTING CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)			
				1)	2)	3)	4)
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE			INITIALS:			DATE:	

Question Details

- 1) Emergency indicating button/lamp visible and verified to be operational (if applicable).
- 2) Associated emergency ballast tested and operation verified (if applicable).
- 3) Occupancy sensor and associated fixture(s) tested and operation verified (if applicable).
- 4) Lighting control schedules programmed and operation verified for all associated fixtures (if applicable).

Negative Responses

Group/Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

D) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
				NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
<input type="checkbox"/> CHECKLIST GROUP COMPLETE				INITIALS: _____				DATE: _____					

Question Details

- 1) Protective covering removed.
- 2) Lens, trim ring and other architectural accessories installed.
- 3) Recessed fixtures are flush to finished surface with no visible gaps.
- 4) Code-required hardware is installed to secure recessed grid-supported fixtures in place.
- 5) Recessed fixtures in fire rated assemblies have been sealed per manufacturer and specification requirements to maintain assembly rating.
- 6) Number and type of lamps specified for each fixture installed and operational.
- 7) Fluorescent lamps installed in fixtures with dimming ballasts have been burned in at 100% rated output for a minimum of 100 hours.
- 8) Fixture adjusted and aimed for specific task or effect per contract documents and/or Architect's directions.
- 9) All damages to fixture finish repaired.
- 10) Fixtures and lens are clean.

Construction Verification Checklist
26 51 13 – Interior Light Fixtures, Lamps and Ballasts

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

1
2
3 **SECTION 26 24 16**
4 **PANELBOARDS**
5 **BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23**

6 **PART 1 - GENERAL**
7

8 **SCOPE**

9 The work under this section includes main, distribution and branch circuit panelboards. Included are the
10 following topics:

11
12 **PART 1 - GENERAL**

13 Scope
14 Related Work
15 References
16 Submittals
17 Operation and Maintenance Data
18 Spare Parts

19 **PART 2 - PRODUCTS**

20 Branch Circuit Panelboards
21 Coordination Branch Panelboards
22 Coordination of Overcurrent Protective Devices

23 **PART 3 - EXECUTION**

24 Installation
25 Field Quality Control
26 Construction Verification Items
27 Agency Training
28

29 **RELATED WORK**

30 Applicable provisions of Division 1 govern work under this Section.
31 Section 26 08 00 - Commissioning of Electrical
32 Section 01 91 01 or 01 91 02 – Commissioning Process
33

34 **REFERENCES**

35 ANSI C57.13 – Instrument Transformers
36 NEMA AB 1 - Molded Case Circuit Breakers
37 NEMA KS 1 - Enclosed Switches
38 UL-891 - Dead Front Switchboards
39

40 **SUBMITTALS**

41 Include outline and support point dimensions, voltage, main bus ampacity, circuit breaker arrangement and
42 sizes, and interrupting ratings confirming a fully-rated system for all equipment and components.
43

44 Submit required short circuit coordination study per specification section 26 05 73 to the consulting engineer
45 for review and approval. Submittal shall be on or before date of panelboard equipment submittal.
46

47 **OPERATION AND MAINTENANCE DATA**

48 All operations and maintenance data shall comply with the submission and content requirements specified
49 under section GENERAL REQUIREMENTS.
50

51 **SPARE PARTS**

52 Keys: Furnish 2 keys for each panelboard to Owner.
53

54 Handle lock-off: Furnish (2) 20/1P circuit breaker handle lock-off devices for each panelboard to Owner.
55

56 One set of three spare fuses of each size and type utilized.
57

58 **PART 2 - PRODUCTS**
59
60
61

62
63 **BRANCH CIRCUIT PANELBOARDS**

64 Lighting and Appliance Branch Circuit Panelboards: Circuit breaker type.

1
2 The panelboard and overcurrent devices contained within shall be **fully-rated**.

3
4 Enclosure: Type 1. Minimum cabinet size: 5-3/4 inches (144 mm) deep; 20 inches (508 mm) wide with 5"
5 minimum gutter space top and bottom. Constructed of galvanized code gauge steel. Panel enclosure (back
6 box) shall be of non-stamped type (without KO's) to avoid concentric break out problem.

7
8 Cabinet front cover and cabinet shall be Type 4X, 304 stainless steel in wet and damp locations including
9 kitchen, food service and therapeutic/pool applications.

10
11 Provide surface cabinet front with concealed trim clamps, concealed hinge and flush cylinder lock all keyed
12 alike. Front cover shall be hinged to allow access to wiring gutters without removal of panel trim. Hinged
13 trim shall be held in place with screw fasteners. Finish in manufacturer's standard gray enamel.

14
15 Provide metal directory holders with clear plastic covers. Holder to be factory mounted.

16
17 Provide panelboards with copper bus (phase buses, bus fingers, etc.), ratings as scheduled on Drawings.
18 Provide ground bars in all panelboards. Phase, neutral and ground bar terminations can be dual rated ALCU9.
19 All spaces shall have bus fully extended and drilled for the future installation of breakers.

20
21 Incoming conductors shall terminate at lug landing pads rated for the panelboard.

22
23 Provide compression type lugs to accommodate the conductor shown on drawings.

24
25 Minimum System (i.e. individual component) Short Circuit Rating: As shown on the Drawings and as
26 required by short circuit/ coordination study.

27
28 Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers. Provide UL Class A
29 ground fault interrupter circuit breakers as shown on Drawings. Provide circuit breakers UL listed as Type
30 HACR for air conditioning equipment branch circuits.

31
32 Do not use tandem circuit breakers.

33
34 Circuit breakers shall be bolt-on type with common trip handle for all poles. No handle ties of any sort will
35 be approved.

36
37 Provide a minimum of 10% spare circuit breakers in branch panelboards.

38
39 All of the panelboards provided under this section shall be by the same manufacturer.

40
41 All panelboards installed side by side (double tub) shall utilize same enclosure height.

42
43 Double tub panelboard installations shall identify type of feed to adjacent panelboard- sub-feed or feed-thru.
44 Identification shall be integral with panel label.

45
46
47
48 **COORDINATION OF OVERCURRENT PROTECTIVE DEVICES**

49 Provide a coordination study of the electrical system and recommend set points for all of the overcurrent and
50 ground fault trip adjustments on the equipment provided. The coordination study and set point
51 recommendations shall be submitted to the consulting engineer for approval. Submittal shall be on or before
52 date of switchboard and panelboard equipment submittal. The study shall meet the requirements of
53 specification section 26 05 73.

54
55
56
57
58 **PART 3 - EXECUTION**

59
60 **INSTALLATION**

61 See section 26 05 29 for support requirements.

62
63 Install panelboards plumb with wall finishes.

1 Height:
2 Power Distribution panelboards: Minimum 12" above finished floor and maximum of 6'-7" to center
3 of the grip of the operating handle of the top most mounted switch or circuit breaker, when at its
4 highest position.
5
6 Branch panelboards: 6'-0" to top of panelboard.
7
8 Install a crimp type stud termination to stranded conductor when terminating on circuit breakers without a
9 captive assembly rated for terminating stranded conductors.
10
11 Provide filler plates for unused spaces in panelboards.
12
13 See section 26 05 53 for identification requirements. Provide typed circuit directory for each panelboard per
14 NEC 408.4(A). Revise directory to reflect circuiting changes required to balance phase loads.
15
16 Stub three (3) empty ¾" conduits to accessible location above ceiling or below floor out of each recessed
17 panelboard. Cap these conduits to prevent material from entering them.
18
19 **FIELD QUALITY CONTROL**
20 If aluminum conductors sized #1/0 and larger (per Section 26 05 19) are to be used as panelboard feeders, it
21 is the responsibility of the contractor to provide panelboards with adequate wire bending space to
22 accommodate the aluminum conductors and terminators to meet allowable code requirements.
23
24 The Contractor shall circuit the panelboards as shown on the drawings. Measure steady state load currents at
25 each panelboard feeder. Should the difference at any panelboard between phases exceed 10 percent,
26 rearrange circuits in the panelboard to balance the phase loads within 10 percent.
27
28 Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding.
29 Check proper installation and tightness of connections.
30
31 **CONSTRUCTION VERIFICATION**
32 Contractor is responsible for utilizing the construction verification checklists supplied under specification
33 Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01
34 or 01 91 02.
35
36 **AGENCY TRAINING**
37 All training provided for agency shall comply with the format, general content requirements and submission
38 guidelines specified under Section 01 91 01 or 01 91 02.
39
40

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

PART 1 - GENERAL

SCOPE

This section describes the products and execution requirements relating to furnishing and installing wiring devices and related systems for the project. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- Submittals
- Operation and Maintenance Data

PART 2 - PRODUCTS

- Device Colors
- Device Plates and Box Covers
- Wall Switches
- Receptacles
- Cord Reels
- Motion Sensors (Occupancy and Vacancy)
- Emergency Lighting Control Units (ELCUs)
- Photocells

PART 3 - EXECUTION

- Installation
- Field Quality Control
- Motion Sensors
- ELCU Wiring
- Adjusting

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

- Section 01 91 01 or 01 91 02 – Commissioning Process
- Section 26 09 43 – Distributed Digital Lighting Controls

SUBMITTALS

Provide product data showing model numbers, configurations, finishes, dimensions, and manufacturer's instructions.

For motion sensor shop drawings, the manufacturer's actual layout of motion sensors and the wiring diagrams shall be provided.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

DEVICE COLORS:

Device colors shall be selected by project architect's interior designer and coordinated with Agency representative during shop drawing review.

All switches and convenience outlets on emergency circuits shall have a red handle or red face with matching red cover plate.

DEVICE PLATES AND BOX COVERS

Weatherproof Cover: All receptacles installed in wet locations shall have an enclosure that is weatherproof whether or not the attachment plug is inserted. Covers shall be gasketed metal with hinged

1 “in-use” device covers, powder coat painted. Non-metallic covers are not allowed. Covers shall be latching
2 type and shall be lockable. Covers shall be identified as “extra-duty” type per NEC 406.9(B)(1).
3

4 **Damp Location Cover:** All receptacles installed outdoors in a location protected from the weather or in
5 other damp locations shall have an enclosure that is weatherproof when the receptacle is covered
6 (attachment plug not inserted and receptacle covers closed). Covers shall be gasketed metal with hinged
7 device covers, powder coat painted. Non-metallic covers are not allowed.
8

9 **Surface Cover Plate:** Raised galvanized steel.
10

11 WALL SWITCHES

12 **General:** Heavy duty use toggle switch, rated 20 amperes and 120/277 volts AC. Switches shall be UL20
13 Listed and meet Federal Specification WS-896. All switches shall be heavy duty Specification Grade.
14

15 Handle: Made of nylon or high impact resistant material.
16

17 **Wall Switches for Lighting Circuits and Motor Loads Under 1/2 HP:** All switches shall be back- and
18 side-wired, screw clamp type, suitable for solid or stranded wire up to #10 AWG, with separate green
19 ground screw. Switches shall be as follows:
20

21 Hubbell 1221*,
22 Leviton 1221-S*,
23 Pass & Seymour CSB20AC1-*,
24 or approved equal. (* indicates color selection).
25
26
27
28

29 RECEPTACLES

30 **General Requirements:** NEMA Type 5-20R, Nylon or high impact resistant face. Receptacles shall be
31 UL498 Listed and meet Federal Specification WC-596. All duplex receptacles shall be heavy duty
32 Specification Grade, 20 amp rated.
33

34 Generally, all receptacles shall be duplex convenience type unless otherwise noted.
35

36 All receptacles on emergency circuits shall have a red face with matching red cover plate.
37

38 All receptacles designated as isolated ground shall have an isolated ground triangle
39 imprint on the face of the receptacle.

40 All receptacles installed in bathrooms, kitchens, and within 6 feet of the outside edge of sinks shall be
41 GFCI type.
42

43 All receptacles installed in outdoor locations, garages, rooftops, and in other damp or wet locations shall be
44 GFCI type with a weather-resistant (WR) rating.
45

46 **Convenience and Straight-blade Receptacles:** All receptacles shall be back- and side-wired, screw clamp
47 type, suitable for solid or stranded wire up to #10 AWG, with a separate green ground screw. Receptacles
48 shall be as follows:
49

50 Hubbell 5362*,
51 Leviton 5362-S*,
52 Pass & Seymour 5362*,
53 or approved equal. (* indicates color selection).
54

55 **GFCI Receptacles:** Duplex convenience receptacle with integral ground fault current interrupter meeting
56 the requirements of UL standard 943 Class A, including self-test functionality and reverse line-load misfire
57 function repeatability. GFCI receptacles shall be as follows:
58

59 Hubbell GFR5362SG*,
60 Leviton GFNT2-*,
61 Pass & Seymour 2097*,
62 or approved equal. (* indicates color selection).
63

64 **GFCI Receptacles with a weather-resistant (WR) rating:** Weather-Resistant duplex convenience
65 receptacle with integral ground fault current interrupter meeting the requirements of UL standard 943
66

1 Class-A, including self-test functionality and reverse line-load misfire function repeatability. WR GFCI
2 receptacles shall be as follows:
3 Hubbell GFR5362SG*,
4 Leviton GFWR2-*,
5 Pass & Seymour 2097TRWR*,
6 or approved equal. (* indicates color selection).
7
8

9 **Specific-use Receptacle Configuration:** As indicated on drawings.

10 **Modular Convenience and Straight-blade Receptacles:** Receptacles shall be as follows:
11 Hubbell SNAP5362*A,
12 Leviton M5362-S*,
13 Pass & Seymour PT5362*,
14 or approved equal. (* indicates color selection).
15
16

17 **CORD REELS**

18 **General:** Provide as scheduled. Cord reels shall be as follows:
19 LeGrand Pass & Seymour 1000 series.
20 Graco SD series.
21 or Reelcraft L-Series Premium Duty.
22
23

24 **MOTION SENSORS (OCCUPANCY and VACANCY)**

25 **Digital Motion Sensors:** Low-Voltage motion sensors that are part of a Digital Lighting Control System:
26 Refer to specification section 26 09 43 Distributed Digital Lighting Controls.
27
28

29 **General Requirements:**

30 All motion sensors shall be hardwired type; battery type shall not be permitted.

31
32 Sensors shall use either passive infrared, or if dual technology, passive infrared and passive acoustic
33 sensing or passive infrared and ultrasonic sensing for detecting room motion.
34

35 Sensitivity shall be user adjustable or self-adjusting type.

36
37 The delay timer shall be adjusted within a range of 6 to 30 minutes by the contractor in the field. The
38 sensor shall have a test mode for performance testing.
39

40 The test LED shall indicate motion.

41
42 Line voltage sensors are acceptable, especially in exposed ceiling areas where all wiring shall be installed
43 in conduit, including low voltage cabling if power packs are used. Provide power pack as required for low
44 voltage sensors.
45

46 See drawings for actual types of sensors.

47
48 Vacancy sensors shall allow for manual-ON and automatic-ON operation.
49

50 Motion sensors and power packs shall have five-year warranties.
51

52 **Wall Mounted (Wall Switch Type):** The unit shall fit in/on a standard single gang switch box.

53 Rated capacity: 600 watts minimum at 120 volts, 60 Hz; 1000 watts minimum at 277 volts, 60 Hz.

54 The sensor shall have two switches where dual-level lighting is required. The switch shall have manual
55 override for positive OFF and automatic ON.

56 The area of coverage shall be approximately 180 degrees by 35-40 feet.
57
58

59 **Ceiling Mounted:** The unit shall fit in/on a standard octagon box. All ceiling mounted sensors shall be
60 installed to a box with ring and box support.
61

62 The coverage area shall be 360 degrees by approximately 15 feet radius when mounted at 9-foot height.
63 The sensor shall have provisions, such as masking, to block out problem areas.
64

1 **Ceiling/Corner Mounted:** The unit shall fit in/on a standard octagon box. All ceiling mounted sensors
2 shall be installed to a box with ring and box support.

3
4 The coverage area shall be 90 degrees or greater by approximately 40 feet radius when mounted at 9-foot
5 height. The sensor shall have provisions, such as masking, to block out problem areas.

6
7 **Power Packs:** Provide power packs as required for low voltage sensors. Rated capacity shall be 20 amps at
8 120 or 277 volts for fluorescent lamps.

9
10 The unit shall fit on a standard octagon box. All power packs shall be installed onto a supported box.

11
12 Low voltage cabling shall be plenum rated or installed in conduit in plenum-rated areas.

13
14 **Auxiliary Contacts for HVAC Interlock:** Provide auxiliary dry contacts for HVAC BAS interlock when
15 required. Refer to the "Occ Sensor Interlock" column in the Air Terminal Schedule(s) on the HVAC
16 drawings. When required, provide auxiliary contacts regardless if the motion sensors are line- or low-
17 voltage.

18
19 The motion sensors and auxiliary contacts shall be wired such that the sensor still detects motion and
20 controls the auxiliary contacts regardless if the light switch(es) are in the OFF position (e.g., the occupant
21 has turned the lights OFF because there is enough daylight, but the occupant is still occupying the space,
22 and the motion sensor senses the occupant and closes the auxiliary contacts for BAS input).

23
24 The BAS wiring to the auxiliary contacts shall be by the Division 23 contractor.

25 26 **EMERGENCY LIGHTING CONTROL UNITS (ELCUs)**

27 **General Requirements:** Emergency Lighting Control Units (ELCUs) shall automatically illuminate
28 connected emergency lighting upon utility power interruption, regardless of room switch position or motion
29 sensor state.

30
31 ELCUs shall be UL 924 listed.

32
33 Warranty shall be 5-year replacement warranty.

34
35 Local room switch or lighting control shall turn both normal and emergency luminaires ON at the same
36 time (no dedicated emergency room switch required).

37
38 The ELCU shall have a minimum load rating of 20 Amps at 120V or 277V, 1800W Tungsten at 120V,
39 1500W Tungsten at 277V, 1 HP, or general use 20 Amp circuits.

40
41 The ELCU shall accept 120V or 277V, 60Hz Input & Output (voltage tolerance +/- 15%).

42
43 The ELCU shall include emergency power and normal power indicator LEDs, and a manual test switch.

44
45 The ELCU shall accept separate phases on the constant hot and switched hot inputs.

46
47 The ELCU shall include high voltage input surge protection up to 50,000V.

48
49 Load contacts shall be able to withstand 10 direct shorts while connected to a 20 Amp breaker without
50 permanent damage.

51
52 The ELCU shall not generate any objectionable electrical or mechanical noise.

53
54 The ELCU shall have UL 94-VO or UL 94-5VA flame rating and be approved for installation above the
55 suspended ceiling.

56 57 **PHOTOCELLS**

58 The controller shall be rated 2000 watts tungsten at 120, 240 or 277 volts. The cell shall be cadmium
59 sulfide, 1" diameter.

60
61 The enclosure shall be die-cast zinc, gasketed for maximum weather proofing.

62
63 The enclosure shall include the positioning lug on the top of the enclosure.
64

1
2 The unit shall have a delay of up to two minutes to prevent false switching. ON/Off adjustment shall be
3 done by moving a light selector with a range from 2 to 50 foot-candles.
4
5 Mounting shall be for a 1/2" conduit nipple.
6
7 The unit shall have a 5-year warranty.
8
9 The contacts shall be SPST normally closed.
10
11 The operational temperature range shall be -40 to 140 degrees F (-40 to +60 degrees C).
12
13
14 The switch shall have zero crossing circuitry.

15 **PART 3 - EXECUTION**

16 **INSTALLATION**

17 See plans for device mounting heights.
18
19 Install wall switches with OFF position down.
20
21 Wall dimmers: de-rate ganged dimmers as instructed by manufacturer; do not use common neutral.
22
23 Install convenience receptacles with grounding pole **ON TOP**.
24
25 Install box for information outlet at the same height as adjacent convenience receptacles. Locate boxes for
26 information outlet as close as practical to duplex power outlet, approximately 2-inches apart.
27
28 Install box for telephone jack for wall telephone at 46-inches to center above finished floor.
29
30 Install specific-use receptacles at heights shown on Contract Drawings.
31 Install decorative plates on switch, receptacle, and blank outlets in finished areas.
32
33 Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible
34 ceilings, and on surface-mounted outlets.
35
36 Install devices and wall plates flush and level.
37
38 Receptacles shall have a bonding conductor from grounding terminal to the metal conduit system. Self-
39 grounding receptacles using mounting screws as bonding means are not approved.
40
41

42 **FIELD QUALITY CONTROL**

43 Inspect each wiring device for defects.
44
45 Operate each wall switch and sensor with circuit energized, and verify proper operation.
46
47 Verify operation of each ELCU by turning off the normal power circuit breaker at the panelboard.
48
49 Verify that each receptacle device is energized.
50
51 Test each receptacle device for proper polarity.
52
53 Test each GFCI receptacle device for proper operation.
54
55 The user agency and DFD personnel reserve the right to be present at all tests.
56
57

58 **MOTION SENSORS**

59 Power packs used in return air plenum ceiling areas shall be installed in an approved enclosure or UL listed
60 for return air plenum.
61
62
63
64

1 Provide a minimum of 4' of coiled cable for ceiling-mounted sensors.
2

3 Motion sensors shall be installed at locations indicated on the manufacturer's submittal layout drawings.
4 Sensors shall be located to prevent false "ON" tripping of the lights.
5

6 Sensitivity Test: After the sensor has been energized for at least 15 minutes, walk to the middle of the room
7 (if conference room), or sit at the normal desk position (if an office). Make no motion for 20 seconds.
8 Move one arm up and down slowly. The test LED should blink.
9

10 Time Delay Test: Set the time delay for 10 minutes. Walk into the room to activate the sensor then leave
11 room. Sensor must turn lights off at approximately 10 minutes. Walk into the room again to reactivate the
12 lights. Lights should activate within 1 second.
13

14 **ELCU WIRING**

15 For lights on emergency power *without* an emergency lighting control unit (ELCU), use the *emergency*
16 circuit to energize the motion sensor's power pack or Digital Load Controller. Route the emergency circuit
17 through the motion sensor's power pack or Load Controller's relay to the light fixtures. Route any non-
18 emergency circuits controlled by the same motion sensor/Load Controller through separate auxiliary
19 relays/Digital Auxiliary I/O Interface Modules.
20

21 For lights on emergency power *with* an ELCU, route the *normal* power through the switches and motion
22 sensor or Load Controller relay to the ELCU, then to the normal power lighting fixtures. Connect the
23 emergency circuit to the ELCU's emergency power terminals, then to the emergency lighting fixtures. The
24 ELCU will control the emergency lighting along with the normal lighting controls, but will turn the
25 emergency lights ON in a power outage, regardless of the position of the switches or Load Controller relays
26 (ON or OFF).
27

28 **ADJUSTING**

29 Adjust devices and wall plates to be flush and level.
30

31 Mark all conductors with the panel and circuit number serving the device with a machine generated label,
32 at the device, and on the back of the device cover.
33

34 **END OF SECTION**

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SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/21

PART 1 - GENERAL

SCOPE

The work under this section includes enclosed circuit breakers. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- References
- Submittals
- Operation and Maintenance Data
- Regulatory Requirements
- Delivery, Storage, and Handling

PART 2 - PRODUCTS

- Circuit Breakers
- Ratings
- Enclosure
- Accessories

PART 3 - EXECUTION

- Installation
- Adjusting
- Field Quality Control
- Construction Verification Items

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 26 08 00 - Commissioning of Electrical.
Section 01 91 01 or 01 91 02 – Commissioning Process

REFERENCES

NEMA AB 1 - Molded Case Circuit Breakers
NEMA KS 1 - Enclosed Switches

SUBMITTALS

Include circuit breaker ratings, withstand ratings, frame size, time-current and let-through current curves, outline dimensions, and terminal lug sizes.

Documentation shall be provided for Arc Energy Reduction where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200A or higher.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

REGULATORY REQUIREMENTS

Circuit breakers listed by Underwriter's Laboratories, Inc., and suitable for specific application.

DELIVERY, STORAGE, AND HANDLING

Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

PART 2 - PRODUCTS

CIRCUIT BREAKERS

Molded Case Circuit Breakers: Inverse time with integral thermal and instantaneous magnetic trip elements in each pole.

1 Electronic Trip Circuit Breaker: As scheduled on the drawings, electronic circuit breakers shall have, at a
2 minimum, adjustments for long time trip, short time trip and instantaneous trip.

3
4 Provide integral ground fault sensing with adjustable ground fault trip where indicated on the drawings.

5
6 Provided for Arc Energy Reduction where the highest continuous current trip setting for which the actual
7 overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200A or higher.

8
9
10 **RATINGS:**

11 Ratings as shown on the Drawings.

12
13 **ENCLOSURE**

14 Enclosure:

15 Indoor: NEMA Type -1 code gauge steel with rust inhibiting primer and baked gray enamel finish.

16
17 Outdoor: NEMA 3R code gauge zinc coated steel with baked gray enamel finish

18
19 Corrosive Areas, Kitchen/Food service areas, Therapeutic/Pool spaces and Damp/Wet locations:
20 NEMA type 4X, 304 stainless steel with brushed finish.

21
22
23 **PART 3 - EXECUTION**

24
25 **INSTALLATION**

26 Install enclosed circuit breakers where shown on Drawings, in accordance with manufacturer's instructions.

27
28 Install free standing enclosed circuit breakers on a 3.5 inch high concrete equipment pad.

29
30 Install 90 degree C insulated conductors based on ampacity of 75 degree C conductors when utilizing 100%
31 rated OCPD's. Consult manufacturer's requirements for specific devices.

32
33 **ADJUSTING**

34 Adjust all operating mechanisms for free mechanical movement.

35
36 Adjust trip and time delay settings to values as recommended in coordination study or as instructed by the
37 A/E. Include a copy of the coordination study and recommended circuit breaker set points in the O&M
38 manual

39
40 **FIELD QUALITY CONTROL**

41 Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

42
43 Check tightness of accessible bolted bus joints using a calibrated torque wrench. Tightness shall be in
44 accordance with manufacturer's recommended values.

45
46 Touch up scratched or marred surfaces to match original finish.

47
48 Inspect visually and perform several mechanical ON-OFF operations on each device.

49
50 **CONSTRUCTION VERIFICATION**

51 Contractor is responsible for utilizing the construction verification checklists supplied under specification
52 Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01
53 or 01 91 02.

54
55 **END OF SECTION**

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SECTION 26 51 13
INTERIOR LIGHTING FIXTURES, LAMPS, AND BALLASTS
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/21/22

PART 1 - GENERAL

SCOPE

The work under this section includes interior luminaires and accessories, exit signs, and building-mounted exterior lighting. Included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- Reference Standards
- Submittals
- Operation and Maintenance Data
- Extra Materials
- Definitions

PART 2 - PRODUCTS

- Interior Luminaires and Accessories
- General Use Lamps
- LED Luminaires
- LED Drivers

PART 3 - EXECUTION

- Installation
- Adjusting and Cleaning
- Interface with Other Products

- Field Quality Control
- Luminaire Connections
- Construction Verification Items
- Agency Training

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

- Section 01 91 01 or 01 91 02 – Commissioning Process
- Section 26 08 00 – Commissioning of Electrical
- Section 26 27 26 – Wiring Devices

REFERENCE STANDARDS

- RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
- LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
- LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
- TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

SUBMITTALS

Include outline drawings, lamp and ballast data, support points, weights, accessory information and performance data for each luminaire type.

For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers and required accessories:

- Luminaire:
 - Manufacturer and catalog number,
 - Type (identification) as indicated on the plans and schedule,
 - Delivered lumens,

- Input watts,
- Efficacy,
- Color rendering index.
- Driver:
 - Manufacturer and catalog number,
 - Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
 - Power Factor, Crest Factor, THD, etc.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

EXTRA MATERIALS

Provide one (1) of each type of luminaire.

Provide one (1) LED driver of each type.

DEFINITIONS

Driver: The power supply used to power LED luminaires, modules, or arrays.

L70, L70, or L70%: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LED's original light output.

LED's: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars or arrays, complete with driver.

LED luminaire failure: Negligible light output from more than 10 percent of the LEDs, or less than 70 percent of the listed lumen output constitutes luminaire failure.

PART 2 - PRODUCTS

INTERIOR LUMINAIRES AND ACCESSORIES

See the Luminaire Schedule on the drawings for types of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires and meet the intent of the design.

Luminaire shall be listed by a NRTL (Nationally Recognized Testing Laboratory: e.g. UL, ETL, etc.).

Provide luminaires with quick-connect disconnecting means similar to Thomas & Betts Sta-Kon.

GENERAL USE LAMPS

General Use Incandescent Lamps and Incandescent Reflector Lamps are prohibited. Use LED retrofit lamps or LED luminaires in lieu of incandescent or halogen luminaires. LED retrofit lamps shall be:

- Rated for the voltage of the incandescent lamp/luminaire they are replacing.
- Dimmable where required as indicated on the plans.
- Rated for the luminaire in which they are being installed. Verify whether the luminaire is enclosed and whether the LED retrofit lamp is rated for enclosed luminaires and the temperatures that will be encountered.
- LED lamps/luminaires shall provide delivered footcandles equal to or greater than the footcandles provided by an equivalent incandescent lamp/luminaire.
- LED retrofit lamps shall have an average rated life of 25,000 hours, minimum.
- Lamp color temperature shall be nearly equal to the incandescent lamp it is replacing.

All lamps shall be new.

LED LUMINAIRES

- LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights

1 Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria.
2 The technical requirements that the luminaire shall meet for each Application Category are:

- 3 ○ Minimum Light Output.
- 4 ○ Zonal Lumen Requirements.
- 5 ○ Minimum Luminaire Efficacy.
- 6 ○ Minimum CRI.
- 7 ○ L70 Lumen Maintenance.
- 8 ○ Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all
- 9 LED components.

10
11 *Additional requirements:*

- 12 ● Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on
- 13 the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- 14 ● Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning
- 15 process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior
- 16 luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- 17 ● Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal
- 18 Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior
- 19 luminaires.
- 20 ● Luminaire shall be mercury-free, lead-free, and RoHS compliant.
- 21 ● Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- 22 ● Light output of the LED system shall be measured using the absolute photometry method
- 23 following IES LM-79 and IES LM-80 requirements and guidelines.
- 24 ● Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- 25 ● Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- 26 ● Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- 27 ● Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a
- 28 minimum of 70 for exterior luminaires.
- 29 ● LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of
- 30 the LED for the ambient temperature of the location the luminaire is to be installed. Rated case
- 31 temperature shall be suitable for operation in the ambient temperatures typically found for the
- 32 intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-
- 33 40°C to 40°C).
- 34 ● Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- 35 ● Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power
- 36 and across specified voltage range.
- 37 ● All connections to luminaires shall be reverse polarity protected and provide high voltage
- 38 protection in the event connections are reversed or shorted during the installation process.
- 39 ● All luminaires shall be provided with knockouts for conduit connections.
- 40 ● The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board
- 41 array, and driver(s).
- 42 ● Provide all of the following data on submittals:
- 43 ○ Delivered lumens
- 44 ○ Input watts
- 45 ○ Efficacy
- 46 ○ Color rendering index.

47
48 *LED Luminaires used for Emergency Egress Lighting:*

- 49 ● The failure of one LED shall not affect the operation of the remaining LEDs.

50
51 *Emergency LED Luminaire Compatibility with Inverters:*

- 52 ● Emergency Inverters shall be sine-wave type, or have written confirmation from the luminaire
- 53 manufacturer that the luminaire will function with a square-wave inverter.

54
55
56 **LED DRIVERS**

57 **General:**

- 58 ● Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the
- 59 luminaire schedule on the drawings.
- 60 ● Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
- 61 ● Driver shall have a rated life of 50,000 hours, minimum.
- 62 ● Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
- 63 ● Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at
- 64 full input power and across specified voltage range.

- 1 • Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- 2 • Driver shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power and
- 3 across specified voltage range.
- 4 • Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
- 5 • Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall
- 6 be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per
- 7 Class 2 UL listing.
- 8 • Provide all of the following data on submittals:
 - 9 ○ Input watts
 - 10 ○ Power Factor (pf)
 - 11 ○ Crest Factor (cf) at full input power
 - 12 ○ Total Harmonic Distortion (THD).

13
14 **Dimming Drivers:**

- 15 • LED driver shall be compatible with dimming controls where dimming is indicated on the plans. Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or Pulse Width Modulation (PWM) operation.
- 16
- 17
- 18
- 19 • Step-Dimming Drivers: Easily switched from 0% to 50% to 100% output power. Both switch-leg
- 20 inputs shall control 50% of the luminaire's light output equally.
- 21
- 22 • Continuous Dimming Drivers: LED luminaires shall dim to (10%, 1%, or 0.1%) as specified in the
- 23 Luminaire Schedule on the plans without visible flicker or "popcorn effect". "Popcorn effect" is
- 24 defined as the luminaire being on a pre-set dimmed level (less than 100%), and going to 100%
- 25 prior to returning to the pre-set level when power is returned to the luminaire. Continuous
- 26 Dimming Drivers shall use 0-10V control.

27
28 **PART 3 - EXECUTION**

29
30 **INSTALLATION**

31 Verify ceiling types with Architectural plans or with existing ceilings. Verify specified luminaires are compatible with specified ceiling type(s) prior to ordering luminaires.

32
33
34 Install in accordance with manufacturer's instructions.

35
36 Install suspended luminaires using aircraft cable, or pendants supported from swivel hangers. Heavy duty chain supports may be used where indicated on the luminaire schedule. Provide aircraft cable, pendants, or chain lengths required to suspend luminaire at indicated height. All aircraft cables or pendant supported luminaires shall have an independent support to structure at all cable or pendant support locations. When chain is used, tie-wrap the luminaire wiring method to the chain.

37
38
39
40 Support luminaires larger than 2 x 4 foot (600 x 1200 mm) size independent of ceiling framing.

41
42 Provide independent support for all luminaires over 50 lbs.

43
44 Locate ceiling luminaires as indicated on reflected ceiling plan.

45
46 Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

47
48 The Contractor shall install luminaire supports as required. Luminaire installations with luminaires supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all luminaires adequately, providing extra steel work for the support of luminaires if required. Any components necessary for mounting luminaires shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

49
50
51 Install recessed luminaires to permit removal from below.

52
53 Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.

54
55
56
57 Install code required hardware to secure recessed grid-supported luminaires in place.

1 Install wall mounted luminaires and exit signs at height as scheduled. Use pendants supported from swivel
2 hangers in exposed ceiling/structure locations where necessary to mount exit signs at the specified height.

3
4 Install accessories furnished with each luminaire.

5
6 Make wiring connections to branch circuit using building wire with insulation suitable for temperature
7 conditions within luminaire.

8
9 Bond luminaires and metal accessories to branch circuit equipment grounding conductor.

10 Install specified lamps in each luminaire and exit sign.

11
12
13 HID High-Bay or Low-Bay Luminaires: Use power hook hangers rated 500 pounds (225 kg) minimum and
14 provide safety chain between ballast and structure. Also provide safety chain between reflector and ballast.

15 Dimmed luminaire circuits shall have separate neutrals.

16
17
18 Dimmed LED luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire
19 so that the luminaires don't "glow" at the lowest dimmed setting. This shall be accomplished using a
20 switch, relay, or some other means acceptable to DFD.

21 All new luminaires shall be operational at the Substantial Completion of the project.

22 23 24 **ADJUSTING AND CLEANING**

25 Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and
26 debris from installed luminaires.

27 Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.

28 Touch up luminaire finish at completion of work.

29 30 31 32 **INTERFACE WITH OTHER PRODUCTS**

33 Interface with air handling accessories furnished and installed under Division 23.

34
35 Provide controls as indicated on the plans. Refer to section 26 27 26 - Wiring Devices. Controls shall be
36 compatible with the luminaires/drivers being installed.

37 38 39 **FIELD QUALITY CONTROL**

40 Operate each luminaire after installation and connection. Inspect for proper connection and operation.

41 42 **LUMINAIRE CONNECTIONS**

43 **METAL-CLAD (MC) CABLE WHIPS**

44 Metal-Clad (MC) type cable that combines power and Class 2 circuits into a single cable may be used for
45 luminaire whips where 0-10V dimming control wiring is required. Whips may not exceed six (6) feet in
46 length. Examples of such products are Encore Wire® MC-LED™ or Southwire® MC-PCS Duo™.
47 Manufacturer's names and catalog numbers are used for quality and performance only. MC Cables
48 manufactured by others shall be equally acceptable provided they meet or exceed in performance and
49 quality as specified.

50
51 Chain or Cable Hung (unfinished spaces):

- 52 • Use manufacturer's SO cord or a luminaire fixture whip from a J-box. Luminaire fixture whips
53 shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal
54 Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a
55 single cable may be used as a whip for luminaires that are dimmed.
 - 56 • Conduit whips shall be 3/8" (10 mm) minimum diameter. Conduit whip or SO cord shall be cut to
57 length (six feet (1.8 m) maximum) and shall allow movement of the chain/cable/luminaire, but
58 shall not be long enough to "loop" and shall present a neat and workmanlike appearance.
 - 59 • Luminaire field wired flexible cord installations shall be connected per NEC 410.62.
 - 60 • The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with
61 locknut, or snap-in connector type, including those used on the master-satellite units.
 - 62 • Conduit whip slack shall be tie-wrapped to the chain supports. Tie-wraps shall be UL listed for
63 UV resistance.
- 64

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Surface Mounted (unfinished spaces):
• Provide direct conduit and box connection.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION

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SECTION 26 56 29
SITE LIGHTING
BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/21/22

PART 1 - GENERAL

SCOPE

The work under this section includes exterior luminaires and accessories, poles, and foundations. Also included are the following topics:

PART 1 - GENERAL

- Scope
- Related Work
- Reference Standards
- Definitions
- Submittals
- Project Record Documents
- Operation and Maintenance Data
- Coordination
- Extra Materials

PART 2 - PRODUCTS

- Luminaires
- LED Luminaires
- LED Drivers
- Wiring Connectors

PART 3 - EXECUTION

- Installation
- Field Quality Control
- Adjusting
- Cleaning
- Construction Verification Items
- Agency Training

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

- Section 01 91 01 or 01 91 02 – Commissioning Process
- Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
- Section 26 08 00 – Commissioning of Electrical.

REFERENCE STANDARDS

- Wisconsin Administrative Code SPS 362.1807 Shallow Post Foundations
- International Building Code IBC 1807.3 Embedded Posts and Poles
- RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
- LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
- LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
- TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

DEFINITIONS

Driver: The power supply used to power LED luminaires, modules, or arrays.

L70, L₇₀, or L_{70%}: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LEDs original light output.

LEDs: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars, or arrays, complete with driver.

1 LED luminaire failure: Negligible light output from more than 10 percent of the LEDs, or less than 70
2 percent of the listed lumen output constitutes luminaire failure.

3
4 **SUBMITTALS**

5 Shop Drawings: Indicate dimensions and components for each luminaire, pole, and base.

6
7 **Product Data:**

8 For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog
9 numbers, and required accessories:

- 10
11 • Luminaire:
- 12 ○ Manufacturer and catalog number,
 - 13 ○ Type (identification) as indicated on the plans and schedule,
 - 14 ○ Delivered lumens,
 - 15 ○ Input watts,
 - 16 ○ Efficacy,
 - 17 ○ Color rendering index,
 - 18 ○ Performance data, and
 - 19 ○ Effective Projected Area (EPA).
- 20 • Driver:
- 21 ○ Manufacturer and catalog number,
 - 22 ○ Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
 - 23 ○ Power Factor, Crest Factor, THD, etc.
- 24

25 **Manufacturer's Instructions:**

26 Indicate application conditions and limitations of use stipulated by product testing agency specified
27 under "Regulatory Requirements".

28
29 Include instructions for storage, handling, protection, examination, preparation, installation, and
30 starting of product.

31
32 **Light Layout:** Provide a computer-generated factory point-by-point foot-candle layout of the project for each
33 area involved.

34
35 **Post Installation Report:** Provide to the Engineer and DFD the results of the measured foot-candle level for
36 each area involved. Use a measuring device pre-approved by DFD.

37
38 **PROJECT RECORD DOCUMENTS**

39 Accurately record actual locations of each luminaire, pole, and underground circuit.

40
41 Provide record drawings of the final, as installed and measured, point-by-point foot-candle layout for each
42 area involved.

43
44 **OPERATION AND MAINTENANCE DATA**

45 All operations and maintenance data shall comply with the submission and content requirements specified
46 under section GENERAL REQUIREMENTS.

47
48 **COORDINATION**

49 Use bolt templates and pole mounting accessories to install anchor bolts in pole base.

50
51 **EXTRA MATERIALS**

52 Provide one (1) of each type of LED module, light bar, or array (if applicable). If the LEDs are integrated
53 into the luminaire and are not separate components, then provide one (1) of each of these types of luminaires.

54
55 Provide one (1) LED driver of each type.

56
57 Provide five (5) percent of total fuses provided for each size, but not less than one (1) of each size.

58
59 **PART 2 - PRODUCTS**

60
61 **LUMINAIRES**

62 See the Luminaire Schedule on the drawings for type of luminaires and catalog numbers. Catalog numbers
63 are shown on the drawings for quality and performance requirements only. Luminaires manufactured by

1 others are equally acceptable provided they meet or exceed the performance of the indicated luminaires and
2 meet the intent of the design.

3
4 Luminaire shall be certified by a Nationally Recognized Testing Laboratory (UL, ETL, or IEC).

5
6 Provide luminaires with quick-connect disconnecting means, similar to Thomas & Betts Sta-Kon.

7 8 **LED LUMINAIRES**

- 9
- 10 • LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product
11 Qualification Criteria. This does not require that the luminaire be listed on the DesignLights
12 Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The
13 technical requirements that the luminaire shall meet for each Application Category are:
 - 14 ○ Minimum Light Output.
 - 15 ○ Zonal Lumen Requirements.
 - 16 ○ Minimum Luminaire Efficacy.
 - 17 ○ Minimum CRI.
 - 18 ○ L70 Lumen Maintenance.
 - 19 ○ Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all
20 LED components.

21 *Additional requirements:*

- 22 • Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on
23 the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- 24 • Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning
25 process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior
26 luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- 27 • Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal
28 Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior
29 luminaires.
- 30 • Luminaire shall be mercury-free, lead-free, and RoHS compliant.
- 31 • Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- 32 • Light output of the LED system shall be measured using the absolute photometry method following
33 IES LM-79 and IES LM-80 requirements and guidelines.
- 34 • Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- 35 • Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- 36 • Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- 37 • Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a
38 minimum of 70 for exterior luminaires.
- 39 • LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of
40 the LED for the ambient temperature of the location the luminaire is to be installed. Rated case
41 temperature shall be suitable for operation in the ambient temperatures typically found for the
42 intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-
43 40°C to 40°C).
- 44 • Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- 45 • Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power
46 and across specified voltage range.
- 47 • All connections to luminaires shall be reverse polarity protected and provide high voltage protection
48 in the event connections are reversed or shorted during the installation process.
- 49 • All luminaires shall be provided with knockouts for conduit connections.
- 50 • The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board
51 array, and driver(s).
- 52 • Provide all of the following data on submittals:
 - 53 ○ Delivered lumens
 - 54 ○ Input watts
 - 55 ○ Efficacy
 - 56 ○ Color rendering index.

57 *LED Luminaires used for Emergency Egress Lighting:*

- 58 • The failure of one LED shall not affect the operation of the remaining LEDs.

59 *Emergency LED Luminaire Compatibility with Inverters:*

- 60 • Emergency Inverters shall be sine-wave type, or have written confirmation from the luminaire
61 manufacturer that the luminaire will function with a square-wave inverter.
62
63
64

1 **LED DRIVERS**

2 General:

- 3 • Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the
- 4 luminaire schedule on the drawings.
- 5 • Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
- 6 • Driver shall have a rated life of 50,000 hours, minimum.
- 7 • Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
- 8 • Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full
- 9 input power and across specified voltage range.
- 10 • Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- 11 • Driver shall have a maximum Total Harmonic Distortion (THD) of ≤20% at full input power and
- 12 across specified voltage range.
- 13 • Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
- 14 • Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall
- 15 be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per
- 16 Class 2 UL listing.
- 17 • Provide all of the following data on submittals:
 - 18 ○ Input watts
 - 19 ○ Power Factor (pf)
 - 20 ○ Crest Factor (cf) at full input power
 - 21 ○ Total Harmonic Distortion (THD).

22 Dimming Drivers:

- 23 • LED driver shall be compatible with dimming controls where dimming is indicated on the plans.
- 24 Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or Pulse Width
- 25 Modulation (PWM) operation.
- 26
- 27
- 28 • Step-Dimming Drivers: Easily switched from 0% to 50% to 100% output power. Both switch-leg
- 29 inputs shall control 50% of the luminaire’s light output equally.
- 30
- 31
- 32

33 **WIRING CONNECTORS**

34 Wiring Connectors shall meet the requirements of Section 26 05 19 Low-Voltage Electrical Power

35 Conductors and Cables.

36
37 Twist-On Wire Connectors: Solderless twist-on spring connectors (wire-nuts) with insulating covers for
38 copper wire splices and taps. All wire connectors used in site lighting applications shall be silicone gel-filled
39 twist connectors or connectors designed for damp and wet locations. Gel-filled twist-on connectors may be
40 used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer’s wire
41 fill capacity must be followed.

42
43
44 **PART 3 - EXECUTION**

45 **INSTALLATION**

46 Install in accordance with manufacturers' instructions.

47
48 Minimum underground conduit size is 1 inch.

49
50
51 Underground and exterior wire shall be minimum #8 AWG conductors, type XHHW-2 or USE-2. #10 AWG
52 conductors shall be utilized for vertical wire installed within pole and for overall circuit lengths of less than
53 100 LF.

54
55 Protect anchor bolts 2 inches (50 mm) minimum above base.

56
57 Install all anchor bolts and handhole fasteners with anti-seize compound.

58
59 Install poles plumb. Provide shims or double nuts to adjust plumb.

60
61 Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

62
63 Bond each luminaire, each metal accessory, the UFER ground conductor and the pole to the branch circuit
64 equipment ground conductor with a separate ground wire sized per NEC or as shown on the drawings.

1
2 Dimmed luminaire circuits shall have separate neutrals.
3
4 Dimmed luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire so that
5 the luminaires don't "glow" at the lowest dimmed setting. This shall be accomplished using a switch, relay,
6 or some other means acceptable to DFD.
7
8 **FIELD QUALITY CONTROL**
9 Operate each luminaire after installation and connection. Inspect for improper connections and operation.
10
11 **ADJUSTING**
12 Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.
13
14 All new luminaires shall be operational at the Substantial Completion of the project.
15
16 **CLEANING**
17 Clean photometric control surfaces.
18
19 Clean finishes and touch up damage.
20
21 **CONSTRUCTION VERIFICATION**
22 Contractor is responsible for utilizing the construction verification checklists supplied under specification
23 Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01
24 or 01 91 02.
25
26 **AGENCY TRAINING**
27 All training provided for agency shall comply with the format, general content requirements and submission
28 guidelines specified under Section 01 91 01 or 01 91 02.
29
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END OF SECTION

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